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BULLETIN OF MARINE SCIENCE OF THE GULF AND CARIBBEAN

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PLANKTON OF THE FLORIDA CURRENT. I. GENERAL CONDITIONS¹

S. M. MILLER, H. B. MOORE, AND K. R. KVAMMEN

The Marine Laboratory, University of Miami

ABSTRACT

The hydrography and plankton of the Florida current off Miami were studied from June 1950 to February 1952. At the standard station occupied, *T-S* curves indicated that the surface waters on the Miami side of the current were predominantly of Yucatan Channel origin in the autumn-winter, and of Gulf of Mexico origin in spring-summer. There were temporary fluctuations, and on two occasions a third water mass of untraced origin occurred. Water mass changes were sufficient to mask any seasonal changes in temperature or nutrient salts, and the depth of the 15°C. isotherm proved an even better index of water mass than the *T-S* curve. The phytoplankton concentration generally followed that of nutrients, while that of zooplankton was more complex. An extremely high ratio of filterable nannoplankton to net-caught phytoplankton was found to be typical throughout the period. Fuller reports on the plankton will appear in later papers in this series.

INTRODUCTION

In 1950, the Marine Laboratory, University of Miami, in cooperation with the National Geographic Society, commenced a study of the Gulf Stream System forming the Florida Current. Plankton collections were started in June 1950, and hydrographic observations, in August of that year. A series of papers by different authors will cover special aspects of the study. The present paper presents the hydrographic and general information to which repeated reference will be necessary in later sections. The program as a whole was under the direction of F. G. Walton Smith and H. B. Moore. Hydrographic work and all operations at sea were in the charge of K. V. Kvammen during the first part of the work, and of S. M. Miller later. While E. C. Jones was responsible for plankton collections and for the examination of copepods, various workers have undertaken the study of particular groups. The vessels involved were principally the Marine Laboratory's *Mega-*

¹ Contribution No. 83 from the Marine Laboratory, University of Miami.

lopa, *Mysis* and *T-19*, with some cruises on the Woods Hole Oceanographic Institution's R. V. *Atlantis* and R. V. *Caryn* and the Cuban B. S. H. *Yara*. To all those who have assisted both with advice and in collecting material, and particularly to the National Geographic Society, we wish to express our great indebtedness.

METHODS

The location occupied as a routine station was about ten miles east of the Miami sea bouy ($25^{\circ}43'N$ - $26^{\circ}08'N$, $79^{\circ}56'W$), where there is a depth of over 100 fathoms. The very strong currents made it impossible to hold an exact station throughout the work. One transect from Miami to Cat Key was worked, as well as one between Key West and Havana, Cuba. In addition, three 24-hour stations were occupied, two at the standard locality off Miami, and one between Key West and Havana. An attempt was made to occupy the standard station about every two weeks, but weather and other factors were frequently responsible for longer intervals.

Tows for zooplankton were made with a 70 cm. diameter closing net of the *Discovery* type, in which the leading third consists of $\frac{1}{4}$ "-side mesh, the central third of stramin, and the trailing third of No. 10 silk bolting cloth. These were towed for about one-half hour at the required depth and then closed before being brought up. The samples were preserved in 4% formaldehyde in sea water, buffered with borax. Tows were also made with a Clarke-Bumpus plankton sampler for phytoplankton, and water samples, taken with a five gallon carboy, were used for filtration to estimate nannoplankton. Nansen bottle samples were taken for chemical analyses.

The strong vertical gradient in current in this area makes it very difficult to control the depth at which a net is fishing or to predict the distance it will travel in a given time. In practice it has been found necessary to let the ship drift with the surface current during deep tows, and to steam against the current when towing near the surface above the current discontinuity. A meter which recorded the distance towed and the depth throughout the tow was attached to the cable, close to the net. Details of this instrument are given in the Appendix.

Temperatures were recorded with bathythermographs (450 and 900 foot models) and reversing thermometers. Water samples were taken with Nansen reversing bottles. Water transparency was determined on some occasions with a Secchi disc, and on others with photocells.

LABORATORY PROCEDURE

Zooplankton Volume. The catch was drained for one minute on a silk seive, then transferred to a measuring cylinder containing a known amount of water, and its displacement estimated. Counting techniques, etc., will be referred to in later papers.

Phytoplankton Determination. Method 1. Clarke-Bumpus catches, preserved with formaldehyde, were centrifuged, the supernatant liquid was decanted, and the remainder extracted for 24 hours at room temperature with acetone. Optical density was compared with Harvey standards in a Fisher Electrophotometer. This was standard procedure throughout the work.

Method 2. Twenty liters of surface water were filtered through Whatman No. 54 paper. The retained sample was extracted and the estimation carried out in the same way. On one occasion only, similar samples were taken from depths of 15 and 25 meters and compared with a surface sample. Method 2 was applied at intervals during the last year.

Salinity. Salinity determinations were by standard Knudsen titration methods.

Phosphate. Method 1. Phosphate determinations were carried out on board using the Atkins-Denigés method and visual comparison with standards. With the phosphate concentration in these waters normally lying below 0.1 milligram-atom per M³ in the euphotic zone, this method is inadequate for demonstrating seasonal or other fluctuations. An improved method was therefore developed during the course of the work.

Method 2. The method consists of concentration of phosphate on a magnesium hydroxide precipitate produced by the addition of a small quantity of concentrated sodium hydroxide to the sample. The precipitate is subsequently dissolved and the resulting concentrated phosphate estimated by a modification of the Atkins-Denigés method. This method will be described in detail in a future paper, and at the same time the seasonal distribution of phosphate in the upper waters will be discussed.

Nitrate. Nitrates were determined by the Harvey method, using reduced strychnine.

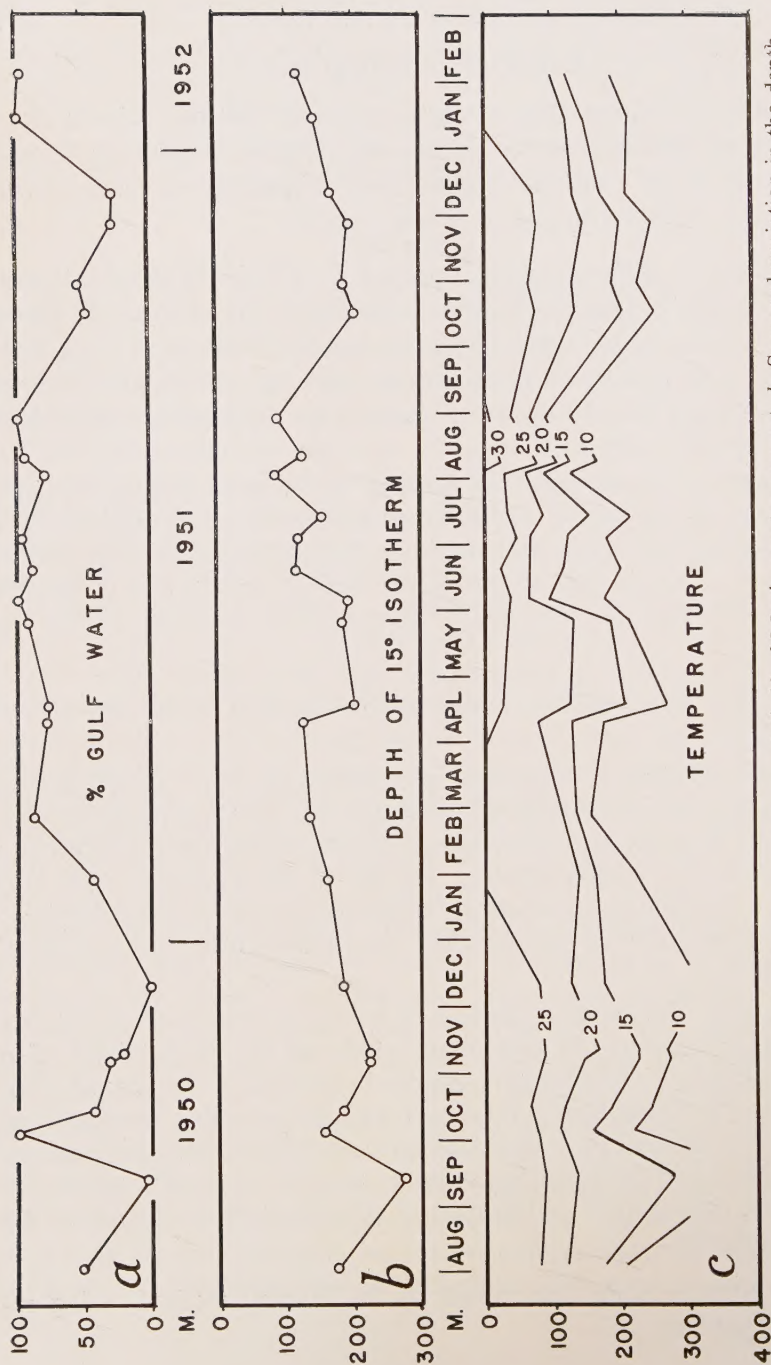


FIGURE 1. *a.* Seasonal variation in the percentage of Gulf of Mexico water present. *b.* Seasonal variation in the depth of the 15°C isotherm. *c.* Seasonal vertical distribution of temperature (°C).

WATER MASS DETERMINATION

Following the work of Parr (1933) and others, it was assumed that the water masses present off Miami originated either in the Yucatan channel or in the Gulf of Mexico. Parr has given typical *T-S* curves for these two masses. With the exception of two periods, the *T-S* curves obtained for our samples fall either between the typical Yucatan and Gulf curves, or within the limits of variation of those observed by Parr. Fortunately, the depths covered in plankton samplings and *T-S* determinations coincide with those corresponding to wide divergence in the typical *T-S* curves. It may be pointed out here that, when Gulf water is present in the Florida Straits, it is usually present as a rather shallow layer extending some quarter of the distance across from Miami. Hydrographic determinations and plankton samplings were made to depths of only 300 meters, the approximate lower limit of this layer. To obtain a crude numerical estimate of the relative abundance of this Gulf water at our station, the following procedure was used. The local *T-S* curve for a particular date was superimposed on Parr's typical Gulf and Yucatan curves. The area lying between it and the Yucatan curve was expressed as a percentage of the area between the Gulf and Yucatan curves. If the local curve crossed either of the other two, it was assumed to have stopped on that curve. The estimate of the percentage of Gulf water is admittedly crude, but it is probably adequate for our purposes of comparison with the abundance of indicator species.

RESULTS

Fluctuations during the year in such factors as temperature, phosphate, etc., appear to be, at least in part, due to fluctuations in water mass. For this reason the discussion of water mass fluctuations is treated first. Figure 1a shows the observed seasonal variation in the percentage of Gulf water at our standard station. The percentages were determined, as described above, from *T-S* curves. There were two periods, one in August 1950, and the second in January 1951, when *T-S* curves which do not fit into this series were obtained. These will be discussed presently. Excepting these two periods, there is an apparent seasonal rhythm with an autumn-winter period of mainly Yucatan water, and a spring-summer period of mainly Gulf water. The results of the second year more or less repeat those of the first. The data are obviously inadequate, at present, to allow more detailed analysis of the minor fluctuations. Support for the validity of the per-

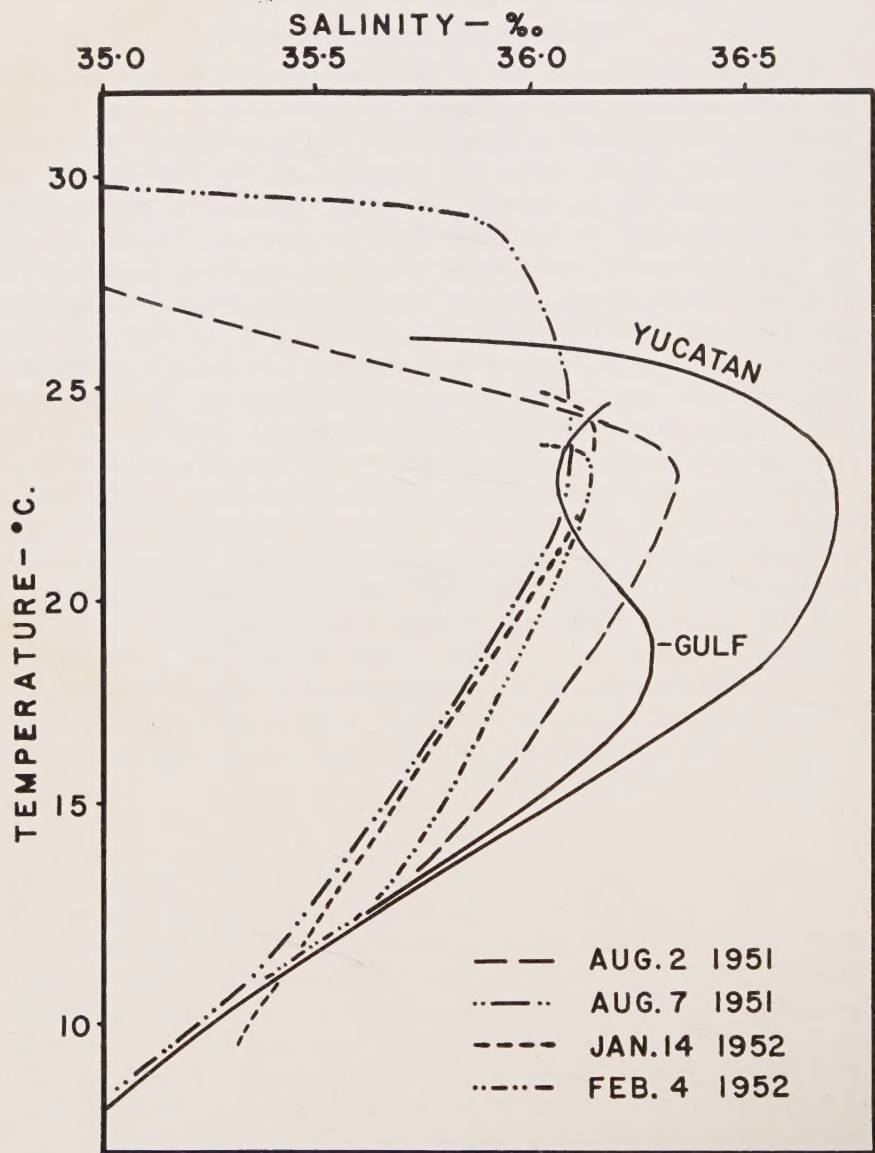


FIGURE 2. Temperature-Salinity relationships between typical Gulf of Mexico and Yucatan Channel water, and water encountered during possible intrusion of Sargasso seawater.

centage determinations which we have made from the T - S curves is obtained from the temperature distribution (Figure 1c). Figure 1b

shows the seasonal variation in the depth of the 15°C. isotherm. For much of the period, the fluctuations in this depth closely parallel the changes in the percentage of Gulf water. If use is to be made of these temperature data as an index of water mass, it must be remembered that there will be some seasonal fluctuation in depth of the 15°C. isotherm within any one water mass. Interpreting the data given by Iselin (1936, p. 34) for the Sargasso Sea, this might be expected to

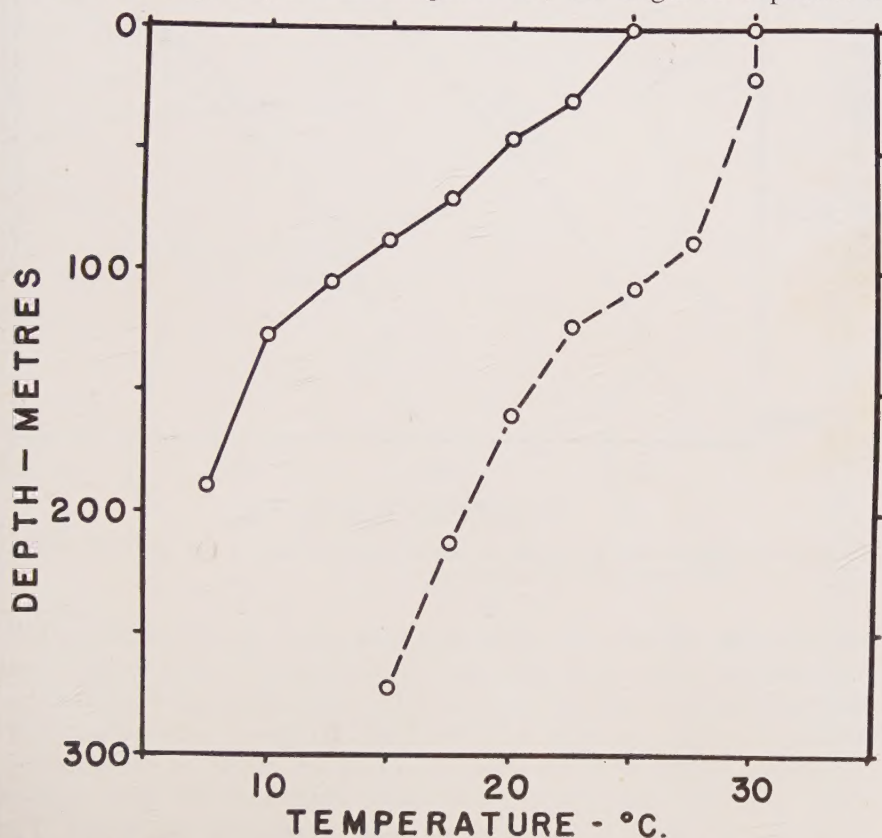


FIGURE 3. Extreme temperature range encountered from August 1950 to February 1952.

be of the order of ten meters, so it seems safe to deduce that most of the observed 180 meters difference found here is due to water mass changes.

In view of the work of Parr (1937) on eddy formation in the neighborhood of our station, and of his suggestion that these eddies may

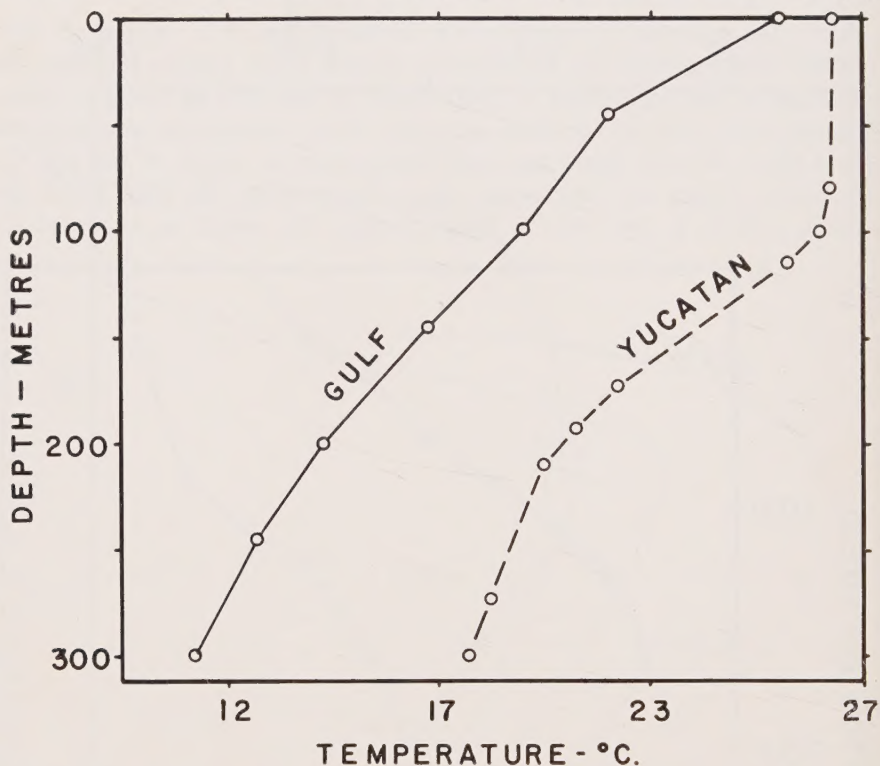


FIGURE 4. Typical vertical distribution of temperature in the Gulf of Mexico and in the Yucatan Channel.

show a tidal rhythm, the possibility arises that the differences which we observed might have been due to a progressive shift in the lunar hour at which we took our samples. This could bring our station either within or outside an eddy, with resulting changes in water mass characteristics. If this were the case, a correlation might be expected between the observed percentage of Gulf water and the time elapsed since the last lunar transit, and no such correlation was found. The possibility remains that some of the minor fluctuations which we observed might be attributable to this cause. Our present knowledge of the characteristics of the eddies is insufficient to make this argument conclusive, but it should be pointed out that, in Key West-Havana sections quoted by Parr (*loc.cit.*), some showed a strip of Gulf water similar to that found in Miami-Cat Key sections, while others showed that such intrusive water was completely absent.

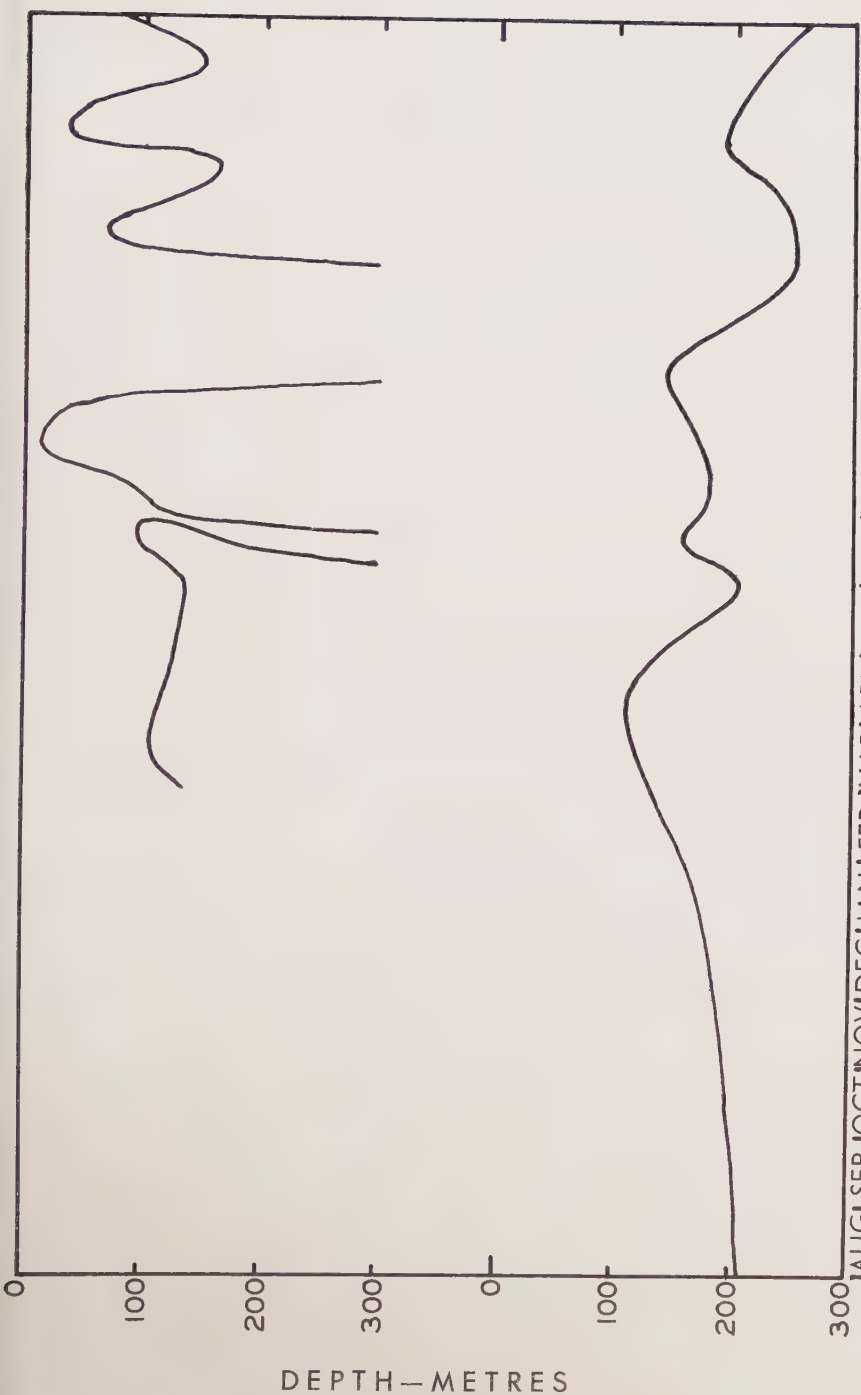


FIGURE 5. Upper curve: depth at which the concentration of nitrate-nitrogen was 20 mg-atoms/ M^3 . Lower curve: depth at which the concentration of phosphate-phosphorus was 1 mg-atom/ M^3 (August 1950 to February 1952).

Longer-continued observations are called for before the possible cause of these fluctuations can be suggested. At the moment, however, it does not appear that they are closely correlated with the seasonal fluctuations in rate of flow of the Florida Current (Hela, 1952).

On August 2nd and 7th, 1951, and again on January 14th and February 4th, 1952, *T-S* curves were obtained which do not fit either the Gulf or Yucatan pattern. These are shown in Figure 2. The water in the top 50 meters in August was very much less saline than normal. From about 50 to 90 meters, the curves fall within the recorded range for the Gulf of Mexico. Below 90 meters the curve is to the left of any recorded Gulf samples, and more closely resembles Sargasso Sea curves given by Iselin (1936). The same is true of the January-February samples, except for the absence of the low salinity surface water. From the plankton content, also, there is indication that we were dealing, on these occasions, with an abnormal water mass. In particular *Sagitta lyra* (Chaetognatha) was abundant on both occasions but was not taken in numbers at any other time. This species is not recorded by Pierce (1951) in his material from closer inshore on the Florida coast, but we have seen it in hauls from deep water in the central Gulf region. On the other hand, we have taken it abundantly in samples from the south-western Sargasso Sea. The possibility that some intrusive Sargasso water may, on occasions, enter the Florida Current must, therefore, be considered, although the evidence is certainly open to alternative explanation.

Temperature. The variation in temperature across the Florida Current is sufficiently covered in the transects given by Parr (loc.cit.). Figure 1c shows the vertical distribution of temperature at our standard station throughout the period of study. While a normal seasonal fluctuation is no doubt present, this is masked, at least at a short distance below the surface, by fluctuations attributable to the water mass intrusion. When the extreme range is plotted against depth, as in Figure 3, it will be seen that the range actually decreases toward the surface. This should be compared with Figure 20 of Iselin (1936). It was stated earlier that the changes in level of the 15°C. isotherm closely paralleled the changes in water mass indicated by *T-S* curves. This is to be expected, since the Gulf water is typically about five degrees colder than that from the Yucatan Channel (Figure 4).

Salinity. The observed salinity range of about 34.5 - 37.0‰ is probably not sufficient in itself to exercise any appreciable biological effect.

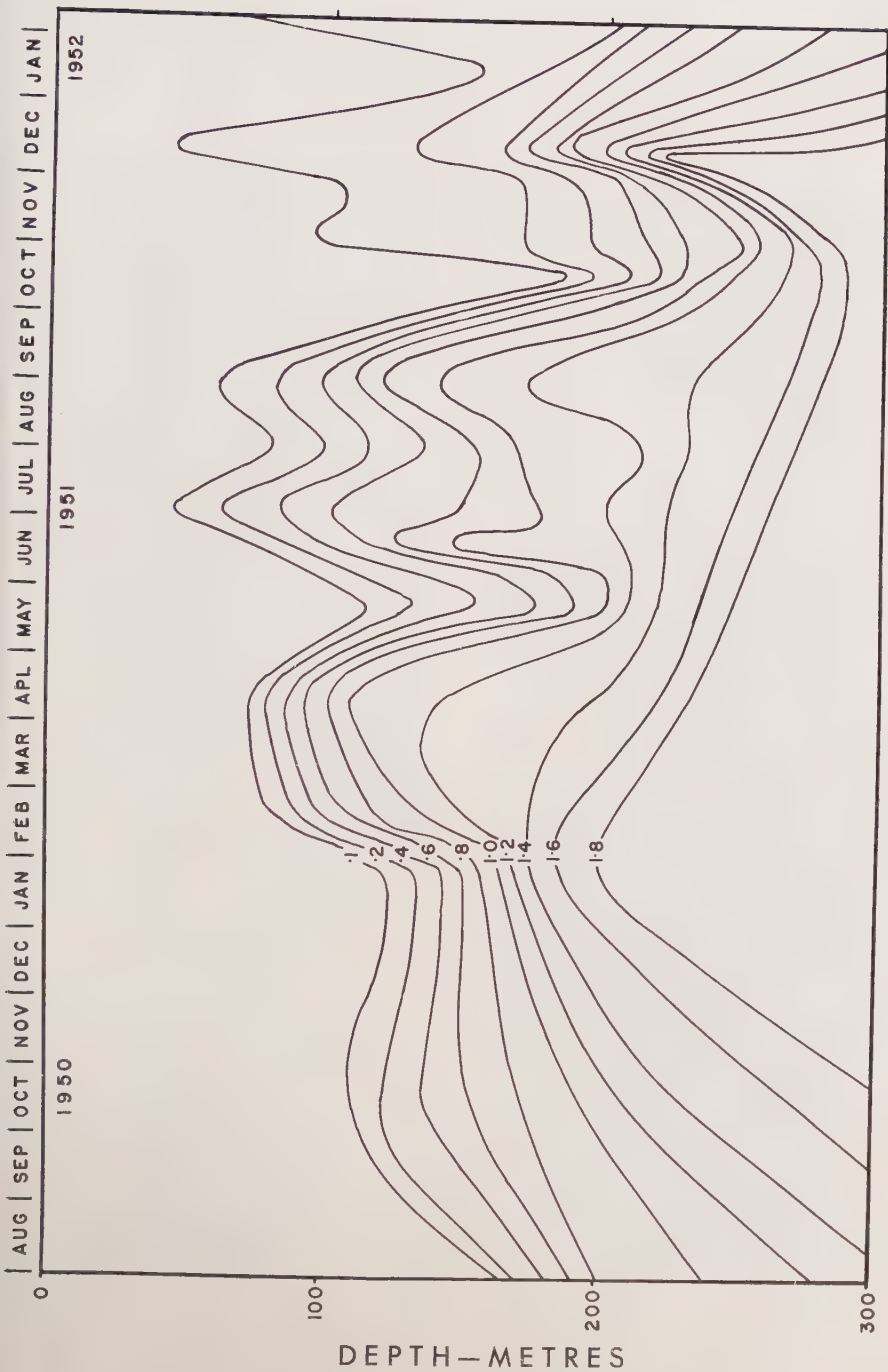


FIGURE 6. Seasonal vertical distribution of phosphate-phosphorus (mg-atoms/M³).

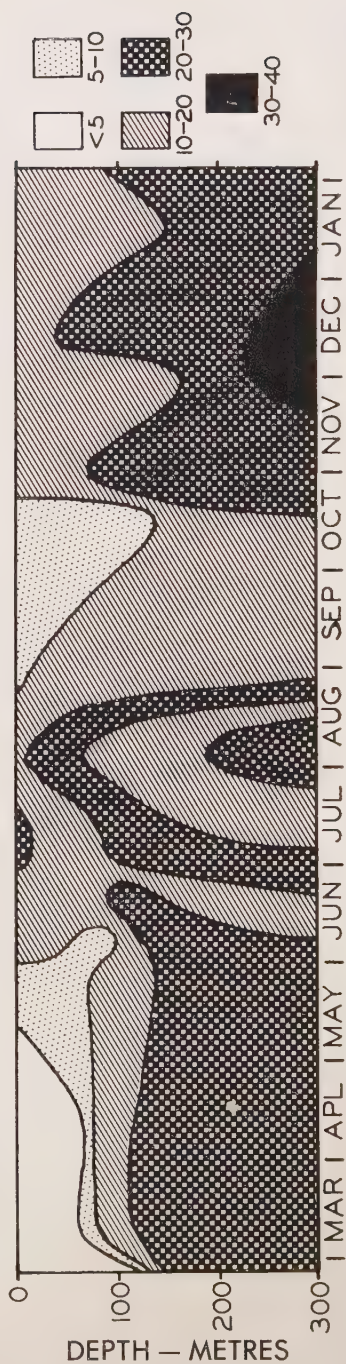


FIGURE 7. Seasonal vertical distribution of salinity (‰) from August 1950 to February 1952.

FIGURE 8. Seasonal vertical distribution of nitrate-nitrogen (mg-atoms/M³) from January 1951 to February 1952.

However, its vertical and seasonal distribution is included here for future reference (Figure 7).

Phosphate. Figure 6 shows the seasonal variation in the vertical distribution of dissolved inorganic phosphorus as determined by the standard methods. Values below 0.1 milligram-atoms per M^3 are at the limit of accurate measurement, and for the surface waters, where the concentration is frequently less than this, the results of the concentration method will have to be considered. Riley *et al.* (1949) gave a limit of 0.55 milligram-atoms per M^3 of phosphate below which the relation of photosynthesis and growth to concentration was more or less linear. Above this limiting value there was little increase in growth and photosynthesis with increased phosphate concentration. The compensation point in our waters is at a depth of approximately 100 meters, and such excess phosphate is never present in the zone of active phytoplankton growth. Below this depth there is, at first, a rapid increase in phosphate concentration, and the level at which this occurs fluctuates very markedly throughout the year. It should be noted that the first period of August 1950—February 1951, was inadequately sampled, and exact details of any rapid fluctuations are therefore lacking for that period.

Information on temperature distribution showed that water mass differences were sufficient to mask any seasonal effect. It seems probable that the same is true of phosphate, particularly in view of the fact that a very much smaller seasonal variation in phosphate is to be expected in tropical waters than is found in temperate waters. Figure 5 shows the seasonal variation in the level at which a concentration of 1.0 milligram-atoms of phosphate per cubic meter occurs, and it will be seen that, with the exception of the 1950 period already noted, the phosphate fairly closely parallels the water mass changes as indicated either from *T-S* curves or from the depth of the 15°C. isotherm. We are not aware of any previous comparison of the phosphate content of Gulf and Yucatan water, but it appears from our results that the upper waters of the Gulf are considerably richer.

Nitrate. The seasonal variation in the vertical distribution of nitrate is shown in Figure 8. The pattern is somewhat similar to that of phosphate but in a more exaggerated form, and it is apparent that there is a dependence of nitrate content on water mass which masks any possible seasonal variation in either factor. While phosphate typically increases rather smoothly—though not linearly—with depth, the ver-

tical distribution of nitrate is much more erratic. With the varying mixture of Gulf and Yucatan water, and the varying depth at which this mixing takes place, it is not surprising that a more complicated picture is obtained for nitrate than for phosphate. The most that can be said at present is that, in general, the Gulf water is also richer in nitrate than the Yucatan water.

The seasonal variation in the depth at which the concentration of nitrate is 20 milligram-atoms per M^3 is shown in Figure 5.

Zooplankton Volume. The series of zooplankton volumes is much less complete than the chemical series. For a considerable part of the survey, it was not possible to meter the water through which the net was towed so the volumes of catch are not quantitative. On still other occasions when the water was metered, an insufficient number of depths was covered to clarify the complicated vertical distribution

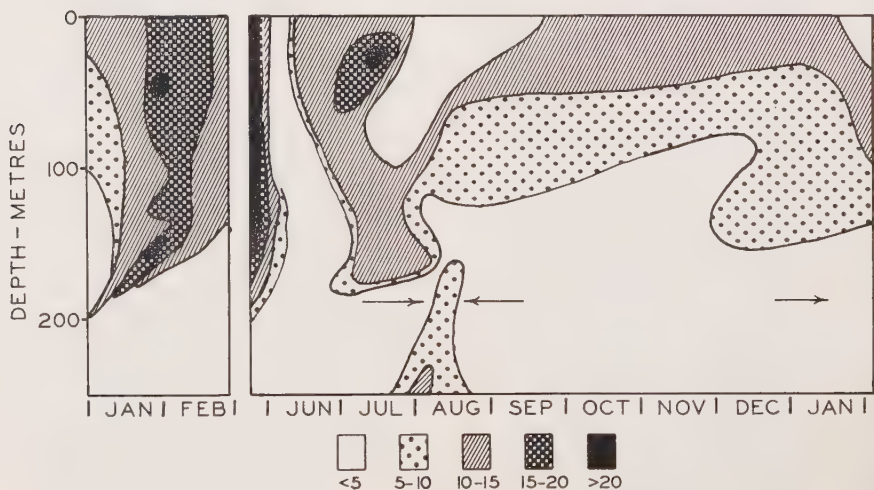


FIGURE 9. Seasonal vertical distribution of zooplankton ($cm^3/mile$) from January 1951 to February 1952. Arrows enclose periods of possible intrusion of Sargasso water.

pattern. That this is complex is shown in Figure 9. Jespersen (1923) found that the macroplankton was quantitatively about twice as abundant in the Gulf as in the Caribbean. While there is a general tendency for plankton to be abundant in areas of rich nutrient supply, this does not always result in a positive correlation between the standing crop of plankton and the phosphate content of the water. In fact, the

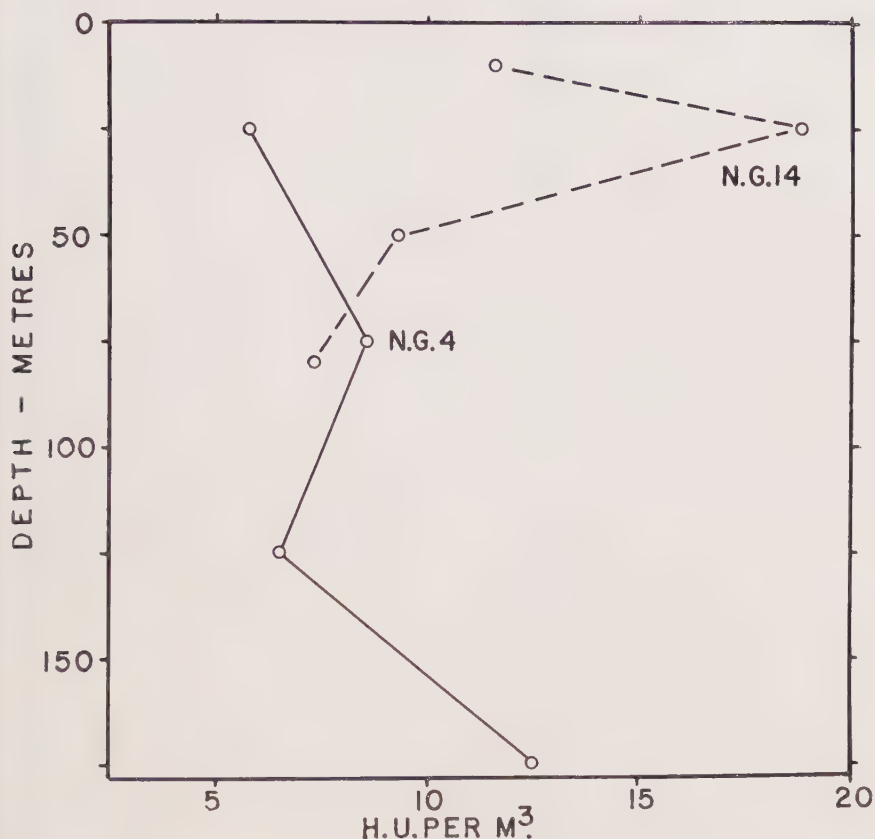


FIGURE 10. Vertical distribution of plant pigment on August 3, 1950 (National Geographic Station 4), and on January 12, 1951 (N.G. 14).

phosphate may become depleted by heavy phytoplankton growth so that a negative correlation is observed for any one place, if all values for the year are correlated (Hart, 1934). The phytoplankton is richest where most phosphate has been removed. While a time lag of some weeks may be expected between the production of a phytoplankton crop and the building up of a large zooplankton population, a similar negative correlation may arise between zooplankton and phosphate. Our data are too few to allow any very definite conclusions to be drawn, and any existing correlation is likely to be masked by water mass changes.

Plant Pigment. The seasonal series of plant pigment determinations

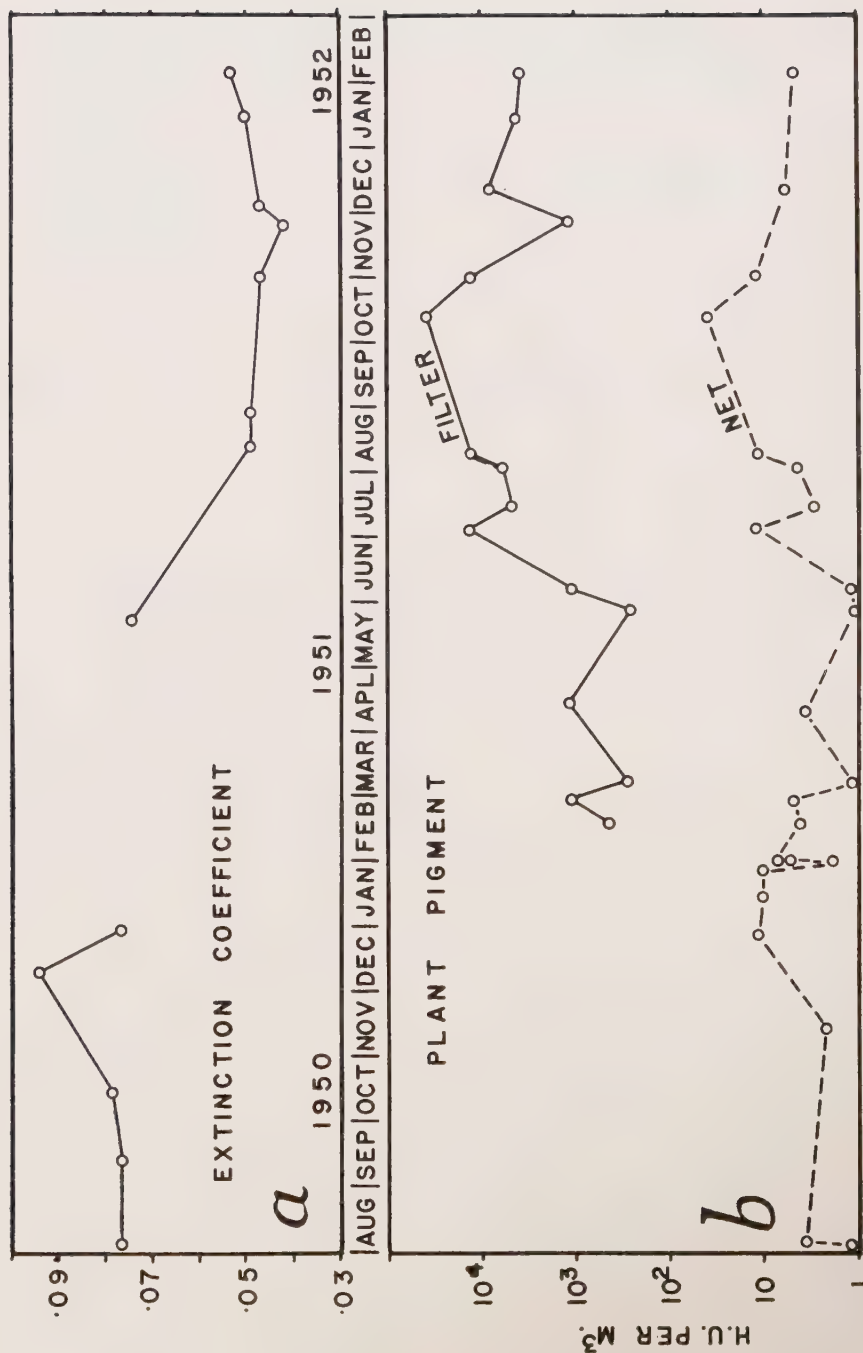


FIGURE 11. *a*. Seasonal variation in the extinction coefficient from August 1950 to February 1952. *b*. Seasonal variation in the surface concentration of plant pigment over the same period.

was made at depths of ten to fifty meters. Only two series of samples for vertical distribution of plant pigment were made (Figure 10), and the two are so different that no general conclusions can be drawn. There is urgent need for extension of this series. Seasonal data are based on Clarke-Bumpus hauls in all but two cases where carboy samples were taken, filtered through paper, and a conversion factor used for the increased retention by paper.

The seasonal fluctuations in plant pigment (Figure 11*b*) show little correlation with water mass, but some with both nitrate and phosphate. Peaks of increased plant pigment in general coincided with peaks of increased nutrients, but it is apparent that these fluctuations are superimposed on some other plant pigment cycle since the pigments showed a general tendency to decrease throughout the period studied, that is to say from March to the following January.

For a series of stations, carboy samples were taken for filtration through Whatman No. 54 paper. When the results of these were compared with those of Clarke-Bumpus tows made simultaneously, a very consistent result was obtained (Figure 11*b*). For one Harvey Unit taken by a Clarke-Bumpus net, 1,260 units are retained by the filter. Various recent estimates have stressed the importance of the nanoplankton which is too small to be retained by a silk net and have emphasized that it may actually bulk much greater than the net fraction. For example, Knight-Jones and Walne (1951) quote examples in which 90% of the phytoplankton passed through a fine silk net and 40%, through a No. 2 filter paper. These were in temperate waters, and it is known (Hart, 1934) that the proportion of dinoflagellates to diatoms increases in tropical waters. Since much of the nanoplankton consists of naked dinoflagellates, it is at least not surprising that the ratio of nanoplankton to net-filtered plankton is larger in Miami waters. Even so, the ratio of over one thousand to one is surprisingly high and raises great doubt as to the validity of previous work on phytoplankton based solely on net hauls. It is of particular interest to note, however, that there was no great variation in this ratio seasonally or over the very wide range of plant pigment concentrations encountered. In the three tests made here using No. 1 filter paper, the ratio observed was about one hundred to one, so about 90% of the phytoplankton must be small enough to pass through this paper. As a check on the correctness of the meter readings on the Clarke-Bumpus sampler, a second meter was substituted, and no change in ratio was found. It still remains to be determined whether

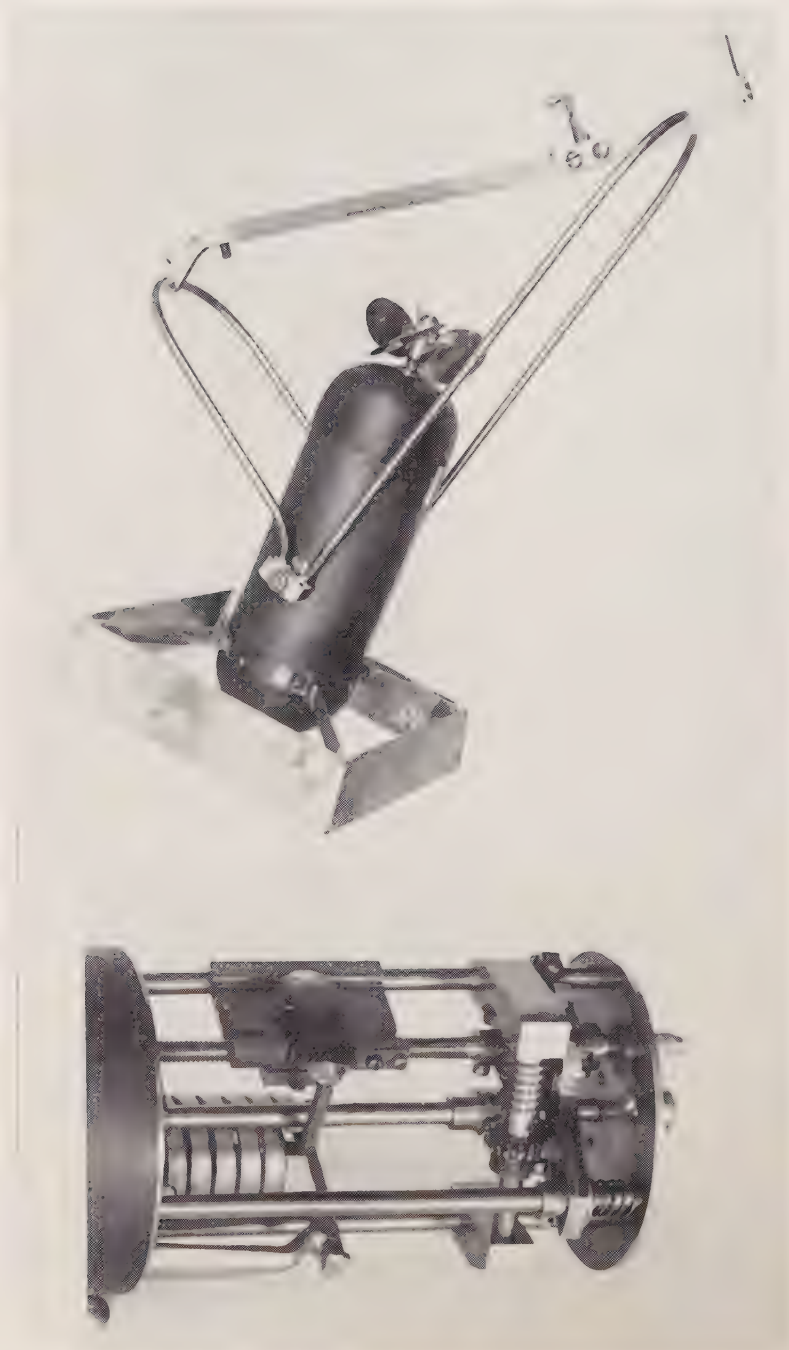


FIGURE 12. Depth-distance recorder complete and with mechanism removed from case to show detail.

the ratio of filter paper to net-retained plankton remains the same at greater depths, since all these determinations were made close to the surface.

Diurnal Migration of Zooplankton. Two 24-hour series of net tows were made for the study of diurnal migration. While these both indicated a night concentration of total plankton toward the surface, the details of this will be discussed in a later paper when the behavior of the individual species is described.

Transparency. The seasonal variation in the extinction coefficient is included here for future reference (Figure 11a).

APPENDIX

DEPTH-DISTANCE RECORDER (FIGURE 12)

Although there is no new principle involved, this instrument seems to deserve a brief description since it is simple to construct, ruggedly built, and has proved comparatively trouble-free during a year of operation. The pressure element consists of a bourdon supplied by the Foxboro Company, Foxboro, Massachusetts. This has a sufficient pressure range to cover a little over 500 fathoms, which is the maximum depth encountered in the Miami area. The bourdon rotates an arm which carries a stilus across a smoked bathythermograph slide carried in a standard B.T. slide holder. The slide holder travels along a slide bar and also along a quarter inch diameter driving screw with 20 threads to the inch. The latter is rotated, through two successive 20:1 worm drives, by the central driving shaft which is driven by the external propeller. Interchangeable propellers with two different pitches are available so that the maximum distance towed can be varied as needed. In a later model than the one illustrated, the threads on the last inch of the driving screw have been cut away so that, in the event of the instrument being towed beyond its maximum range, the slide holder is freed and not jammed against the end of the screw mechanisms. The second worm gear is connected to the driving screw by a dog clutch. When this is disengaged, the driving screw may be spun by a milled end to return the slide holder to its starting position. The mechanism is mounted between two circular brass plates spaced apart by three brass rods, one quarter inch in diameter. Thus all parts are readily accessible. This framework, which carries one plastic end piece and the propeller, slides into an outer brass casing into which it locks with a catch.

The case is supported at its center of gravity in a frame which clamps around the cable. It is free to rotate around a stop which is clamped to the cable. Square fins keep the instrument swimming horizontally. Construction throughout is of brass, except for the rounded plastic caps which streamline the case. All bearings and gears except the screw drive are made with a loose fit to avoid the effects of any corrosion of the brass.

The distance scale of the instrument was calibrated by towing over a measured mile at the standard towing speed of two knots. Pressure calibration was made in a pressure tank in which the whole instrument was immersed. A small solenoid was attached which moved the stylus arm at predetermined pressures. A master grid was then prepared for use in a standard B.T. slide viewer. With the present depth range, depths can be read to the nearest ten fathoms. With the propeller which allows a maximum range of five miles, distances can be read to one-twentieth of a mile, and proportionately less on the shorter range propeller.

We are indebted to Woods Hole Oceanographic Institution for workshop facilities in the construction of the first model, and also for the pressure and distance calibrations of the instrument.

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OBSERVATIONS ON THE NITROGEN AND GLYCOGEN CONTENT OF *TEREDO* (*LYRODUS*) *PEDICELLATA* DE QUATREFAGES AT MIAMI, FLORIDA¹

LEONARD J. GREENFIELD

The Marine Laboratory, University of Miami

ABSTRACT

Monthly analyses of the glycogen and nitrogen content of *Teredo* (*Lyrodus*) *pedicellata* De Quatrefages were accomplished between July 1951 and May 1952. The average glycogen content of the shipworms over 25 mg. dry weight was found to be slightly above 30%. From 0 to 25 mg. dry weight, a steady increase in the percent concentration of this component was apparent. Increasing nitrogen content was observed in the smallest of the specimens until a maximum value of 2.17% occurred in the 10-14.9 mg. weight group. Sexual maturity of *Teredo pedicellata* was achieved in this weight group under the conditions observed.

No seasonal change in the nitrogen and glycogen content was noted, and there was no apparent difference in the concentration of these components between gravid and non-gravid individuals of the same size range.

A greater concentration of glycogen in the prenatal larvae than in the free-swimming larvae was recorded. The possible significance of this is discussed.

The importance of wood used as a source of food in the diet of the organism was also studied. In addition to wood polysaccharide utilization, indications are that wood contains sufficient nitrogen to account for that found in *Teredo pedicellata*. Utilization of plankton as a source of nitrogen was also apparent. This was demonstrated by growing the shipworm in cellulose panels containing no nitrogen.

INTRODUCTION

The food-cycle and environmental relationships of various lamelli-branches have been discussed by Fox (1936, 1951), George (1952), Mansour (1946), Mansour-Bek (1945, 1946), Nelson (1925, 1933), Yonge (1923, 1926, 1930, 1937, 1946) and others. For the most part, these forms feed upon plankton and detritus filtered from the water swept in through the incurrent siphon system. While similar behavior has been ascribed to the lamellibranch *Teredo*, the wood habitat occupied by the organism may also be regarded as a potential food source. The morphology of *Teredo* is such that wood particles scraped off by the action of the shells in boring must pass to the outside through the alimentary tract. A loss of cellulose and hemicellu-

¹ Contribution No. 84 from the Marine Laboratory, University of Miami. These investigations were aided by a contract between the Office of Naval Research and the University of Miami in cooperation with the U. S. Navy Bureau of Yards and Docks.

lose from the wood during this passage was recorded by Dore and Miller (1923), who suggested the possibility that these fractions were digested and metabolized. The likelihood of such behavior was enhanced by the discovery of a cellulytic enzyme system in the shipworm by Boynton and Miller (1927). More indirect evidence has been obtained by demonstrating the survival of shipworms in plankton-free sea water. Roch (1931) exposed wood panels containing *Teredo navalis* to such a medium for an indefinite period, after which no ill effects were apparent. No mention was made, however, of the possible utilization of bacteria or other microscopic material which may have been present. A similar experiment has been performed on *Teredo* (*Lyrodus*) *pedicellata* except that Seitz-filtered sea water was employed (Lane, Posner and Greenfield, 1952). The organisms, *in situ*, were maintained thus for a seven day period with no significant change in carbohydrate content.

Considerable disagreement prevails, however, with regard to the relative importance of wood and plankton in the shipworm diet. Disagreement is especially evident when the metabolism of nitrogenous materials necessary for growth and repair are considered since wood is a poor source of protein. It is even possible that protein balance may be achieved only by the addition of planktonic protein. Kofoid and Miller (1927) and others (Barrows, 1917; Sigerfoos, 1907) have found diatom and other planktonic remains in the gut contents of the shipworm. These investigators imply that plankton is of primary importance as food for marine borers.

Clarification of this problem has been attempted in this laboratory by periodic biochemical analyses of shipworms. From July 1951 to May 1952, monthly analyses of total nitrogen and glycogen as indices of stored protein and carbohydrate were carried out on the local species, *Teredo* (*Lyrodus*) *pedicellata* De Quatrefages. In addition, the ability of the organisms to bore into pure cellulose material was observed.

MATERIALS AND METHODS

Specimens for analysis were obtained by exposing wood panels in Biscayne Bay until they had become infected with teredids. Exposure time varied from one to four months since shipworms of all sizes were desired for study. Beyond the four month period, excessive attack and crowding resulted in the death of most of the individuals and the disintegration of the panels.

Upon removal from the sea water, the collection panels were split lengthwise with a hand axe and the exposed shipworms removed *in toto* with the shell intact. Only whole living specimens were used, since any rupture of tissue would result in the loss of soluble materials vital to the analyses. The shipworms were dried in a vacuum desiccator and weighed individually so that separate chemical determinations could be made on each. Where small size made accurate individual weighing impractical, the specimens were sorted into size groups and the average weight was determined.

Since all of the teredids weighed considerably less than a gram after desiccation, the use of micro-analytical methods was mandatory. For glycogen determinations, the procedure described by Mendel and Hoogland (1950) as adapted by Van Der Kleij (1951) was employed. This method involves the non-destructive extraction of glycogen. The residue remaining after glycogen removal was then analyzed for total nitrogen using the Kirk digestion-diffusion chamber and the Conway-type diffusion cell as described by Kirk (1950).

Additional nitrogen determinations were carried out on both wood and *Teredo pedicellata* obtained from the same exposed panel. Upon the removal of a teredid, a volume of wood equivalent to that of the individual's burrow was obtained. Following this, both were subjected to the same nitrogen analyses used on the other specimens.

In studying carbohydrate utilization, it appeared to be of advantage to determine whether the shipworm was able to bore into pure cellulose material or whether such activity was restricted to wood alone. Artificial panels consisting of regenerated cellulose were fabricated for this purpose, using the method described in Alexander (1946) for the production of Viscose. Briefly, the procedure is as follows. Cellulose fiber sheets are macerated and soaked in an 18% aqueous NaOH solution. This brings about the formation of alkali cellulose which is then drained, shredded and allowed to stand for two days. Following the aging period, during which considerable depolymerization takes place, the alkali cellulose is treated with carbon disulfide, resulting in the formation of the sodium salt of the cellulose ester of dithiocarbonic acid, better known as Cellulose Xanthate. Complete solvation of this substance is accomplished in an aqueous 3% solution of NaOH, and the liquid thus formed is Viscose. Upon standing, the Viscose soon gels, and if allowed to age sufficiently, syneretic extrusion of liquids causes the mass to shrink and form a hard cake. Panels for shipworm attachment were obtained by cutting the cake

into slices of one half inch thickness and treating them with a dilute acid solution to hydrolyze off the xanthate groups. Prior to exposure in the bay, the panels were leached in sea water to remove residual sulfides and other contaminants.

RESULTS

Specimens of *Teredo pedicellata* were collected at monthly intervals from July 1951 to May 1952. At the end of this time 196 individuals had been subjected to analysis. These were grouped into class intervals of 5 mg. dry weight and their separate nitrogen and glycogen concentrations recorded in terms of percent dry weight (Tables I and II). Nitrogen determinations are lacking on some of the individuals so that 179 of the original number are recorded.

The average glycogen content of the shipworms over 25 mg. was slightly above 30% (Fig. 1), and no appreciable change was observed with an additional increment in weight. From 0-25 mg., however, a steady increase in the percent concentration of this component was apparent. In the lowest weight group (0-4.9 mg.) were included the smallest specimens available, many of which had recently attached to the wood and consequently were considered representatives of the early post-larval period. These individuals exhibited low concentra-

TABLE I
RESULTS OF GLYCOGEN DETERMINATIONS ON *T. pedicellata*,
JULY 1951 - MAY 1952

Dry Wt. Range (mg.)	Number of Individuals	Glycogen Range (% dry wt.)	Average % Glycogen	Standard Deviation
0- 4.9	74	08.2-16.1	10.6	2.81
5- 9.9	24	18.8-25.2	22.5	2.76
10-14.9	15	21.9-31.9	26.2	2.87
15-19.9	11	21.0-28.7	24.3	2.94
20-24.9	5	23.2-30.8	28.2	2.59
25-29.9	6	26.5-36.0	31.1	3.21
30-34.9	8	25.8-38.1	30.5	2.38
35-39.9	5	28.6-34.3	31.7	2.27
40-44.9	5	28.0-34.2	31.8	2.19
45-49.9	5	28.5-34.2	31.4	2.25
50-54.9	5	29.7-32.1	31.3	0.93
55-59.9	7	30.5-32.4	32.5	1.21
60-69.9	9	27.4-33.2	30.9	2.42
70-79.9	7	27.9-35.3	32.1	2.54
80-84.9	5	30.7-34.3	32.1	1.32
85-89.9	5	32.3-34.9	33.5	1.09

Total 196

TABLE II
RESULTS OF NITROGEN DETERMINATIONS ON *T. pedicellata*,
JULY 1951 - MAY 1952

Dry Wt. Range (mg.)	Number of Individuals	Nitrogen Range (% dry wt.)	Average % Nitrogen	Standard Deviation
0- 4.9	74	0.55-1.55	0.95	0.293
5- 9.9	24	1.68-2.06	1.91	0.160
10-14.9	6	1.92-2.72	2.17	0.271
15-19.9	9	1.56-2.34	1.89	0.290
20-24.9	5	1.68-2.13	1.97	0.159
25-29.9	6	1.21-2.03	1.81	0.290
30-34.9	7	1.52-2.31	1.89	0.261
40-44.9	5	1.35-2.02	1.73	0.222
45-49.9	5	1.35-1.94	1.71	0.205
50-54.9	5	1.56-2.01	1.79	0.198
55-59.9	7	1.58-2.03	1.76	0.223
60-69.9	9	1.68-2.10	1.71	0.279
70-79.9	7	1.63-1.91	1.75	0.120
80-84.9	5	1.67-1.95	1.76	0.114
85-89.9	5	1.68-1.84	1.78	0.055

Total 179

tions of both glycogen and nitrogen. The maximum nitrogen content, 2.17%, was observed in the 10-14.9 mg. weight group, but beyond this point no further increase was noted. In subsequent weight groups, the values, though slightly lower than 2.17%, did not deviate appreciably from one another (Fig. 2).

The cellulose panel experiments showed no positive results for a short time after the exposure of the material to the sea water. It was assumed that during this time residual side-reaction products from the viscose process were still being leached out. After three months a panel was removed and examined. The entire outer surface was riddled with *Limnoria* burrows, while inside the panel a few *Teredo* borings were found. Undoubtedly more of the latter might have occurred but for the undermining action of *Limnoria*. The shipworms present were of extremely small size, the largest being 9 mm. long with a maximum burrow diameter of 1 mm. The same experiment was repeated with similar success.

DISCUSSION

Glycogen Content in Larval and Post-larval Teredo pedicellata. Free-swimming larvae of *Teredo pedicellata* do not feed, and their dependence upon food reserves passively acquired from the parent shipworm has been described (Lane, Posner and Greenfield, 1952). In

order to ascertain the quantity of stored carbohydrate in these forms, glycogen analyses of prenatal larvae were compared with those obtained from individuals approximately 24 hours in the free-swimming state. It was impossible to obtain those existing beyond the 24-hour period in quantities sufficient for analysis. Furthermore the exact age of the unborn larvae was not known, but that they were close to the point of release from the parent was evidenced by their advanced development and by the fact that some of them began to swim when placed in sea water. The glycogen content in percent dry weight of unborn larvae varied from 10 to 15%, while in those designated as 24-hour larvae, the range was 5-8% (total glycogen appears low because over 50% of the substance of the organism in this stage is the larval chitinous shell). It was evident that a continued free-living existence would deplete the supply of this material to a minimum. Once attachment has taken place and feeding commences, the reserve supply of carbohydrate needed for the resumption of metabolic activity is replenished (Fig. 1).

Nitrogen Content and Sexual Maturity. Among the lower weight groups, increasing nitrogen content was noted with the appearance of maximal values between 10 and 15 mg. This was assumed to be the size range at which sexual maturity of the species is achieved under the conditions observed. A re-check of the descriptions of the specimens taken for analysis confirmed this hypothesis since gravid indi-

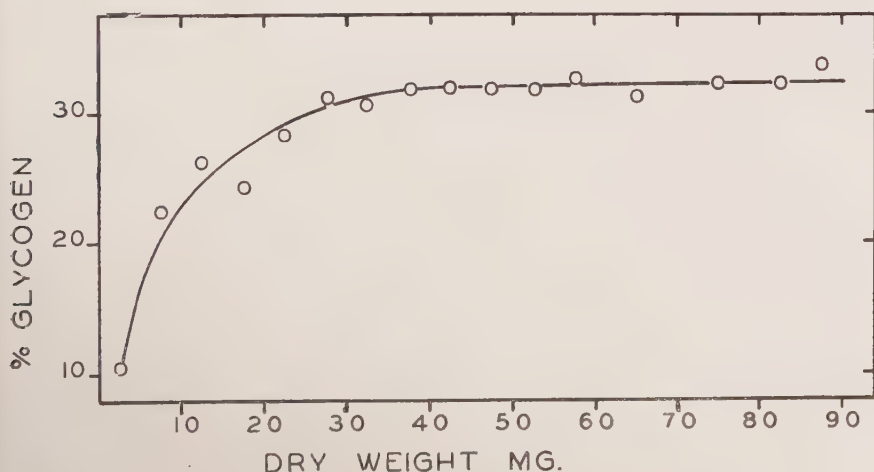


FIGURE 1. Glycogen content of *Teredo pedicellata*.

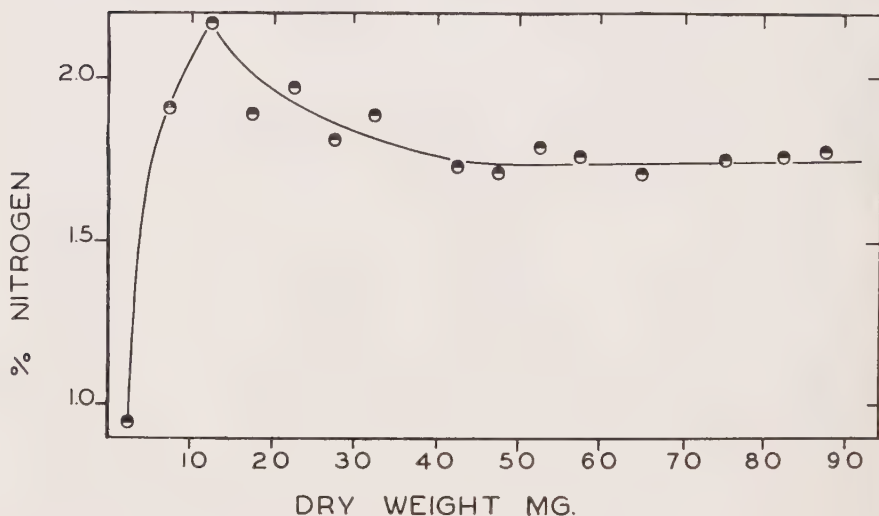


FIGURE 2. Nitrogen content of *Teredo pedicellata*.

viduals were first noted in this weight group. Of the latter, 27 had been collected, one of which weighed 10 mg. while the remaining 26 ranged from 13 to 15 mg.

Seasonal and Sexual Changes in Nitrogen and Glycogen Content. By conducting monthly analyses, the effect of seasonal changes on the nitrogen and glycogen content of *Teredo pedicellata* was determined. The magnitude of these changes was recorded as the standard deviation for each weight group, as shown in Tables I and II. Any variation in the components due to seasonal rhythm would be expected to exhibit a greater order of magnitude than those shown by the actual results. Such behavior may be contrasted with that of other lamelli-branchs not living in wood. The work of Tully (1934) and Milroy (1909) on oyster biochemistry indicates a definite alteration of both protein and carbohydrate during various periods of the year especially in the breeding season. A difference in values between gravid and non-gravid individuals would then be expected. That this was not the case in *Teredo pedicellata* is shown in Fig. 3.

Wood as a Food Source. The lack of significant alteration in the composition of the adult *Teredo pedicellata* suggests the existence of a food supply of rather constant composition and availability. In this respect, wood is a substance worthy of consideration. The production of reducing sugars from wood polysaccharides by means of the cel-

lytic enzyme system may account for the high concentration of glycogen in the organism. Since *Teredo in situ*, provided with plankton-free water, shows little variation in glycogen content, the conclusion appears to be justified that wood polysaccharides are utilized as food.

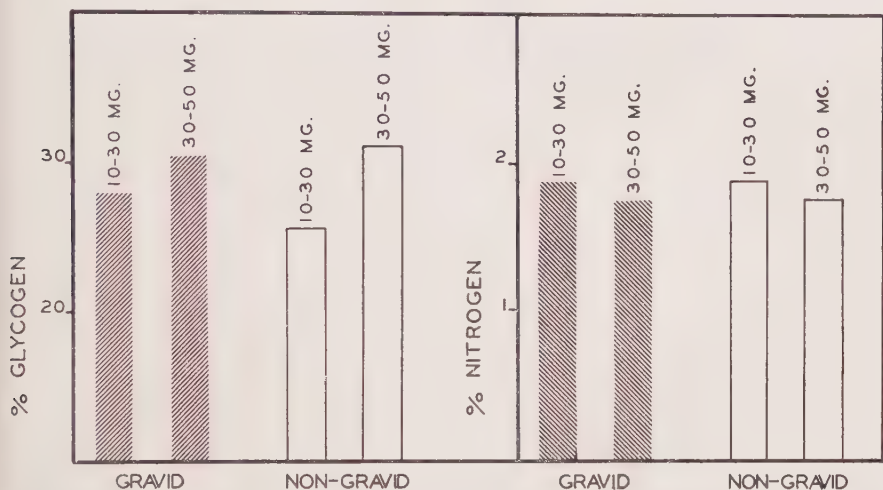


FIGURE 3. Nitrogen and glycogen content of gravid and non-gravid *Teredo pedicellata* of the same size range.

Organic nitrogen present in wood was also considered as a precursor of shipworm protein. The results of the analyses (Table III) reveal that despite the low concentration of wood nitrogen, sufficient quantities were present to account for the amounts found in *Teredo pedicellata*. The volumes of wood used were representative of the shipworm burrow volume in each case and consequently this same volume of wood was presumed to have passed through the shipworm alimentary tract. It is significant that the comparisons of wood nitrogen and *Teredo* nitrogen for each specimen show an excess of this element to have been present in the wood. This would permit the loss of some nitrogen in undigested form. The dry weights of the specimens used were 0.0038, 0.0241 and 0.0344 grams, and the percentages of excess nitrogen were 91.8, 40.8, and 25.6, respectively.

The Kjeldahl procedure used in the nitrogen analyses does not account for that present as alkaloid nitrogen, and it was believed that the results were representative of wood nitrogen exclusive of such compounds. Evidence of this was obtained by Mr. Reuben Lasker, who

found that partial hydrolysis of wood liberated amino acids.

Consideration of the time element in digestion may cast doubt upon the possible nutritive value of a substance as complex as wood. On the other hand, the presence of a large cecum in the digestive tract of the shipworm has been noted by most investigators, and this organ

TABLE III
RESULTS OF NITROGEN DETERMINATIONS ON WOOD* AND *T. pedicellata*
OBTAINED FROM THE SAME PANEL

Sample Analyzed	Volume of Burrow = Volume of Wood (ml.)	Dry Wt. (gm.)	Nitrogen (gm.)	Nitrogen (%)
<i>T. pedicellata</i> Wood	0.53 "	0.0241 0.2692	0.000405 0.000570	1.68 0.260
<i>T. pedicellata</i> Wood	0.08 "	0.0038 0.0407	0.0000532 0.000102	1.40 0.258
<i>T. pedicellata</i> Wood	0.54 "	0.0344 0.3066	0.000536 0.000573	1.56 0.220

*Wood used was clear yellow pine.

may equal or exceed the stomach in size. It is apparently always found full of wood chips and, interestingly enough, rarely contains plankton (Kofoed and Miller, 1927). The presence of a large typhlosole in the ventral wall suggests a digestive function for the cecum. The same authors imply that the large capacity of this organ may allow the wood to remain in it for a great length of time, during which considerable digestion is possible. The unknown factors which remain to be considered are the efficiencies of the digestive enzymes and of the absorptive systems.

Granting the nutritive potential of wood, the presence of plankton in the gut of the shipworm strongly implies a dietary function for these organisms. An example of this was found in the cellulose panels used successfully for the attachment of *Teredo pedicellata* and *Limnoria*. Although these contained sulfide contaminants when placed in sea water, they were nitrogen free. Therefore the nitrogen required for protein synthesis must have come from an outside source—probably planktonic. The teredids observed in this case were of small size, but it is not known whether such a condition was due to nutritional deficiency or to the texture of the cellulose matrix.

The importance of the wood environment in the nutrition of the shipworm is thus emphasized by the gross analyses of glycogen and nitrogen. The digestion and assimilation of the more available wood

fractions, exclusive of alkaloids, lignin and the like, appear probable at this time. This has been demonstrated by means of the cellulytic enzyme system, the high glycogen content, and the relative constance of the components tested. In the final analysis, however, the essential character of certain substances cannot be ignored. Among these are essential amino acids, vitamins, inorganic elements and other growth substances. Whether they are present in sufficient quantities dissolved in the sea water, as fractions of wood or of plankton, or possibly synthesized by the shipworms themselves remains to be investigated.

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SOME PRELIMINARY OBSERVATIONS ON THE YOUNG FORMS OF THE ECHINOID, *DIADEMA ANTILLARUM* PHILIPPI

NORMAN MILLOTT

Department of Zoology, University College of the West Indies, Jamaica, B.W.I.

ABSTRACT

The very young forms of the echinoid *Diadema antillarum* Philippi have been found regularly in only one locality in Jamaica namely, among coral fragments in the calm shallow water covering the landward aspect of a reef near Port Antonio.

Though their general color by day is the same as that of the adult, the spines are banded, the peristome is white and the sub-ambital region of the test is grey. The pattern of blue lines or spots, which is due to iridophores and melanophores, is variable, depending on light intensity. It has but limited significance as a specific character. The structure and development of the iridophores are described and it is suggested that they may be comparable to the so-called "eyes" of *Diadema setosum* (Leske).

The animals react to changes in intensity of illumination by movement of spines, tube feet and pedicellariae which recall those of the adult, but spine movements are irregular and indeterminate, a fact possibly related to the incomplete state of the superficial nervous system.

Despite its spectacular appearance and remarkable reactions to light (Millott, 1950), the common black sea urchin of the Caribbean has attracted little attention from investigators. Observations on the very young forms are especially scanty and although Mortensen (1940) has described the early larva, observations on the stages immediately following metamorphosis in this species appear to be non-existent.

Young forms of *D. antillarum*, the tests of which have an ambital diameter of between 5 and 30 mm., are fairly common in isolated localities (see below), but the very young forms are rarely found around Jamaica, and where the metamorphosis occurs in this area is unknown.

Fortunately a specimen was discovered recently with an ambital diameter of 2.5 mm. (Fig. 1) and this represents the youngest collected as yet in Jamaica. Attempts are being made to rear the larvae but in view of our extremely scanty knowledge of the very young forms of this species it was considered worthwhile to publish forthwith some observations made on these and slightly older specimens.

THE OCCURRENCE OF YOUNG INDIVIDUALS

Although I have by no means searched the entire coast of Jamaica, it is already clear that the distribution of young individuals is limited. Though flocks of adults occur scattered round the coast, young are not found with them. Indeed only one location so far has proved a reliable source of supply over a period of 4 years. This place is the top of the coral reef fringing the deep water channel into Port Antonio. Here large numbers of young, mainly varying in size from 5 to 45 mm. across the ambitus, are found, whilst fully grown forms are relatively few and sometimes absent.

Since no locality in Jamaica so far discovered can compare with this in the abundance of young forms, conditions there must be singular and it is considered pertinent to record them.

The urchins occur all over the reef top in water that rarely exceeds a depth of 2 feet, 8 inches, and in places is much shallower. On the seaward side of the reef, the substratum consists of eroded coral and the extensive wave action compels young urchins to seek shelter in crevices. Towards the shore, however, the substratum consists of extensive areas of *Thalassia*, enclosing patches of fine coral sand and smaller pieces of dismembered reef that have been washed inwards. Here large numbers of young urchins are found, some fully exposed to the intense light, but most in the shade of the larger coral fragments. Although on the seaward side the water is agitated by continuous wave action, on the landward side it is relatively still for long periods each day since the wash is drastically reduced by the reef and the small island on the other side of the channel. In this calm water, temperatures may rise to 32°C. during the afternoons of the summer months. The wealth of food in the form of small organisms which lodges in the rough surface of the disintegrated reef top, together with the shelter afforded by the reef and the related stillness of the water, will obviously contribute to the suitability of the environment for the settling and growth associated with metamorphosis. It is possible too that the relatively high temperatures may prove significant, as well as the fact that little of the reef is ever exposed, since the rise and fall of the tide is only 20 inches on the average.

COLOR

Since color has been accorded some significance in the systematics of the *Diademas* (Mortensen, 1910, 1940), that of young forms may be considered worthy of detailed observations.

In general their color resembles that of the adults, and as in them it varies with the intensity of light and time of day (see below). The strikingly black color of the test develops early, for it appeared even in the specimen 2.5 mm. in diameter. It is due to pigment in large superficial chromatophores. The pigment in the adult has been shown to be a melanin (Millott and Jacobson, 1952).

There are differences, however. As already noted by Mortensen, the spines are conspicuously banded (Figs. 1, 2) and the peristome, usually brilliant red in the adult, is white in the youngest forms. So are the buccal tube feet (though their plantar surfaces are black). The oral spines are white and the sub-ambital portions of the test are grey.

Examination of a series of young specimens leaves no doubt that the two chief pigments, the black and the red, both accumulate with age. In some cases the accumulation of red pigment is such that even the preponderant black color becomes transformed in old specimens into a brown or a dull purple.

The strikingly characteristic blue lines or spots (see below) appeared on the test of all young forms so far studied. In general their distribution is the same as that already described for both *Diadema setosum* (Leske) and *D. antillarum* (Mortensen, 1910, 1940; Delgado y Núñez, 1917; Millott, 1952). Their brilliance in strong light, however, is more pronounced in the young, a fact probably correlated with the accumulation of melanin, for they are always very much more conspicuous in albinistic forms. Their disposition differs slightly in the young, since the peripheral portions of the blue lines run parallel, whereas in older forms they diverge progressively as growth proceeds, owing to the intercalation of spines and tubercles of the lower orders in this area. I have never observed the brilliant green color in these areas described by Delgado y Núñez (1917).

The physiological color change already reported (Millott, 1952), is much more conspicuous in young forms than in adults and was shown by even the smallest individual. This change, to be described in a subsequent account, has considerable significance, for the animal becomes more sensitive to changes in light intensity in dim light when the melanophore pigment is concentrated (Millott, 1950, 1953a). It also accounts for the blue color, for parts which appear blue in bright light go pale and even become pure white (Fig. 3) in dim light or darkness and reassume the blue color when the animal is replaced in bright light.

The reason for this becomes clear when the minute structure of the white or blue areas is studied. In sections these areas show iridophores, either isolated (Fig. 10) or in clusters (Fig. 11), which are always accompanied by melanophores (mph., Figs. 5, 10, 11). When the melanin is concentrated, the iridophores appear white when the urchin is first placed under a bright light, sometimes appearing crystalline and reflecting light with a characteristic sparkle of interference colors. It is in this condition that the test shows the striking white pattern in the interambulacra seen in Fig. 3. On continuous exposure to light, the melanin disperses and the pattern becomes blue, then breaks up into iridescent portions or spots (Fig. 4) and finally disappears, leaving only the well known "white spots."

The blue color thus results from diffraction of light reflected from iridophores, an effect partly due to their structure (see below) and partly due to the dispersion effect of the melanin in superjacent processes of chromatophores. In young forms the white or blue pattern is always strikingly developed in darkness, but in adults there is considerable variation in the extent to which it appears, a fact again known to be related to the accumulation of melanin. Thus sometimes, as in Fig. 4, only the ambital region of the pattern appears, so that a figure resembling the top of a lancet arch results. In other cases further reduction of the pattern results in only the "keystone" of this arch appearing and forming the familiar spot already referred to (Mortensen, 1910, 1940), and again the pattern may not appear at all.

It is indeed surprising that Mortensen appears not to have perceived the relation between the white and blue areas of the test, a relationship which provides the key to a proper evaluation of certain of the so-called color differences. It is equally surprising that he failed to report the remarkable color change, especially as he suspected something of the kind (see Mortensen, 1940, footnote to p. 248) and indeed made specific reference (1940, p. 249) to the obliteration of portions of the white pattern owing to the spreading of chromatophores over it. However, it is not clear from his description whether he regarded this as a morphological or physiological color change.

The mechanism suggested above as responsible for the production of the blue color explains the fact noted by Mortensen, that the color is not retained in preserved forms, for not only would preservation be likely to alter the disposition (and therefore the diffractive properties) of the plates of the iridophores, but it would certainly alter the optical properties of the superjacent surface layer and the dispersion

of melanin. Indeed it has been found that fixatives such as Bouin's fluid frequently disrupt the chromatophores, discharging much of the melanin (d.m., Fig. 10).

The full range of the change in color from dark-adapted to light-adapted phases, when a form 2.5 mm. in diameter was placed under a 40 watt tungsten filament lamp, required only 30 minutes at laboratory temperatures. It thus appears that the change may occur more rapidly in very young forms, for it required 60-90 minutes for a comparable change in forms 18 mm. or more in diameter.

Two points of special interest emerge from the foregoing study of the color of very young forms. Firstly, the fact that the black pigment appears before the red is significant in relation to the suggestion already made (Millott and Jacobson, 1951) that the latter may in some measure serve to poise an oxidation-reduction system controlling melanogenesis. As a result of the foregoing indications that the melanin appears first, this would appear less likely, but the question is being examined more closely in these laboratories. Secondly, the color change necessitates re-examination of the suggestions of Mortensen (1910, 1940), that color differences in *Diademas* may have systematic importance. This matter will be referred to elsewhere (Millott, 1953b). The color differences envisaged apply mainly to the disposition of the blue areas, which in *D. setosum* are said to be isolated spots, whilst in *D. antillarum* the spots are said to be united into continuous lines. Insofar as *D. antillarum* is concerned, this distinction is untenable, for this species may exhibit either lines or spots according to the degree of dispersion of melanin in chromatophores bordering on the white pattern which forms in the interambulacra and, in young individuals, around the periproct as well (see below).

Thus, although I have never seen *D. setosum*, it is clear that any distinction that can be drawn between this species and *D. antillarum* on the basis of this blue pattern is certainly not as simple as that suggested by Mortensen. The fact that Mortensen did not appear to be aware of the full extent of the color change may be responsible for the incorrect statement in his detailed description of the color of *D. antillarum* (1910), that there is no ring around the periproct. A white one appears in young forms after a sojourn in darkness, as Fig. 3 clearly shows, and this becomes blue and then partially or wholly obscured in light! A similar ring was also described by Delgado y Núñez (1917).

It is therefore clear that all descriptions of color and attempts to accord to it systematic significance must be qualified by statements

which take into account not only age, but the different colors developed in light and darkness, and the rhythmic color change previously reported (Millott, 1952), which is independent of environmental lighting.

THE IRIDOPHORES

No satisfactory account of these structures exists and an attempt will be made to deal with them in a separate publication. A few salient features emerging from a study of young forms may be mentioned, however.

Iridophores occur singly or in groups around the spine bases and periproct and in the interambulacral areas which are devoid of spines. To these areas they impart a characteristic blue color under certain circumstances (see above).

In distribution and iridescent properties the iridophores correspond with the blue spots described in *D. setosum* (Sarasin and Sarasin, 1887; Mortensen, 1940), and when the blue lines of *D. antillarum* become broken up by the dispersion of melanin, the similarity is enhanced (Fig. 4).

Although I have not had the opportunity of examining the blue spots of *D. setosum*, I find it difficult to avoid conjecturing that they are produced by the same kind of organ as in *D. antillarum*, for not only are they iridescent and corresponding in distribution in both cases, but Mortensen's description of their minute structure in *D. setosum* as involving a "dense mass of fibrillae wound up like a ball" is also an exact description of their appearance in *D. antillarum*, as the photomicrographs in Figs. 10 and 11 clearly show. It is a great pity that in the figures of his sections, Mortensen does not show the appearance that he describes in his text (1940, plate lxxiii).

The correlation of vertical and horizontal sections of the organs (Figs. 5, 10 and 11), however, suggests that the contents of the organ resemble irregularly corrugated plates rather than fibrillae, and, as suggested by Millott (1953a), it may well be that these, in conjunction with melanin in superjacent melanophores, form the surfaces responsible for reflection and diffraction.

The function of these structures in *D. antillarum* is obscure, but the blue spots of *D. setosum* have been described as "eyes" (Sarasin and Sarasin, 1887; Dahlgren, 1916), a view which Mortensen accepts but with seeming hesitancy (1940, p. 248), and which has been generally accepted and reproduced in standard zoological works. On the other

hand, Cuénot (1891) cautiously throws doubt on the matter: "Comme je n'ai pas examiné les types dont il s'agit, je ne puis émettre une critique positive; mais d'après l'examen du texte et des figures des Sarasins, il me paraît invraisemblable que ces taches bleues soient des organes visuels; elles sont d'abord en nombre considérable (voir les schémas des Sarasins) sur les interradiales, le périprocte, etc., ce qui ne laisse pas que d'être assez exceptionnel; les détails histologiques ne sont guère satisfaisants et plusieurs figures bien plus se rapporter à des grosses cellules muqueuses qu'à des conformations sensorielles. Je crois que les affirmations des Sarasins ne doivent pas être acceptée sans réserve et qu'une confirmation de leurs vues serait loin d'être superflue."

As reported elsewhere (Millott, 1953a), so far as these organs in *D. antillarum* are concerned, on neither histological nor experimental evidence have I yet found good reason for regarding these structures as eyes, and a glance at Fig. 10 is sufficient to show that there is little correspondence between the structure of these organs and those figured and described by the Sarasins in *D. setosum*. It is most significant that Mortensen (1940) makes the same observation from examination of his own sections of the so-called "eyes" of *D. setosum*.

The Sarasins, though putting forward their ideas with reservation and noting that the histology of the "eye spots" is difficult to interpret, figure and describe structures which they regard as corresponding to cornea, lens ("lichtbrechende Körper") and retina. In *D. antillarum*, excepting the provision noted below, I find nothing of these other than the possible representative of a "cornea" in the form of the double layer of flattened cells which covers the organ externally (ep., Figs. 10, 11), and it is a curious fact that the fibrillar appearance noted by Mortensen is not mentioned by the Sarasins.

Although in forms of *D. antillarum* larger than 1 cm. across the ambitus the iridophores only remotely resemble the "eyes" described by the Sarasins, in the very young forms, certain features of the developing iridophores recall features mentioned by them (see below).

In the specimen 2.5 mm. in diameter an incomplete series of stages in the development of these interesting organs can be found (Figs. 6, 7, 8). They appear to arise by differentiation of a few large superficial cells (ir.c., Fig. 6), over which the epithelium covering the test becomes greatly thinned out (c.ep., Fig. 6). By the progressive transformation of their contents, the plates, appearing in sections as fibrils (f., Fig. 11), arise. After the stage shown in Fig. 6, the plates (d. pl.)

separate, become sigmoid (Figs. 7, 8), and finally assume the corrugated form characteristic of the organs in larger urchins, whilst the covering layer becomes double, so that outer and inner layers arise (o.l and i.l., Fig. 8). At certain stages the cells which assume the fibrillar appearance show indications of forming large vacuoles (vac., Fig. 7). This at once recalls the Sarasins's suggestion that the method of formation of the "lichtbrechende Körper" is by vacuolisation of cells beneath the "cornea." Whether some such process as this, occurring in *D. setosum*, is responsible for the Sarasins's ideas must remain obscure, since the size of the specimens they examined is not made clear, and no other detailed description exists.

A most noteworthy feature in the youngest form is the apparent absence of the superficial nerve layer from large areas of the interambulacra which underlie the iridophores. More precise statements must await suitable preparations made by refined or special techniques, but sections prepared by fixation in Bouin's fluid and stained in Delafield's haematoxylin and eosin, showed the following. Although the superficial nerve layer could be seen around the spine bases and in the walls of the tube feet (n.l., Fig. 9), and although the superficial branches of the ambulacral nerves (s.n.l., Fig. 9) from the radial

Diadema antillarum

FIGURE 1. Oral view of youngest individual yet collected, photographed in strong light, x 3.

FIGURE 2. Aboral view of young individual (older than the foregoing) in strong light, x $\frac{1}{3}$. Note uniform black color of test and the banded spines.

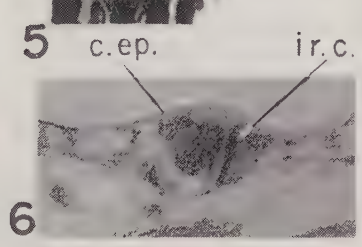
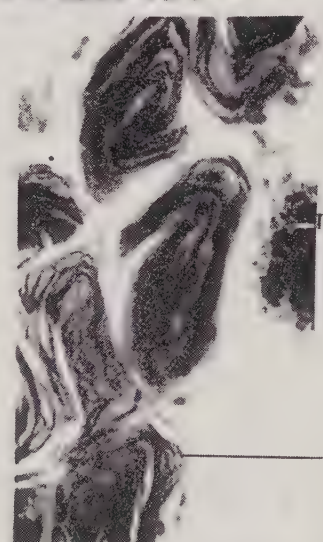
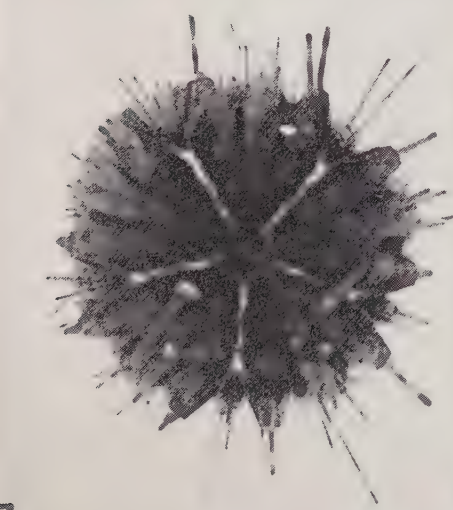
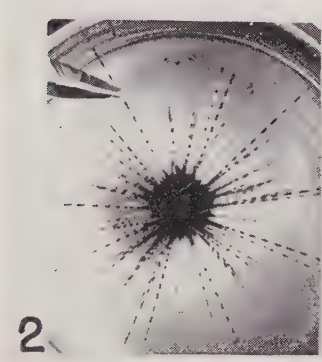
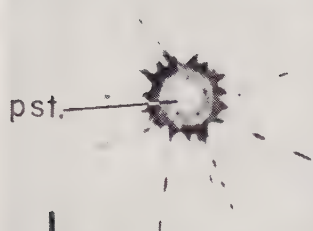
FIGURE 3. Aboral view of young individual in strong artificial light, after three hours in total darkness. Note the white pattern developed on the test around the periproct and in the interambulacra. The spines have been cut short. x 2.

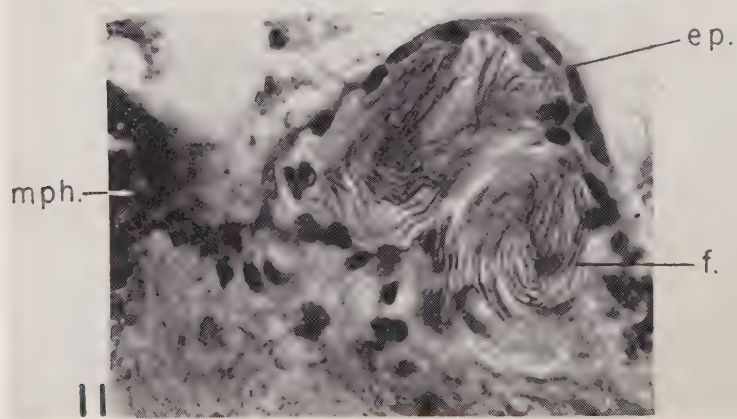
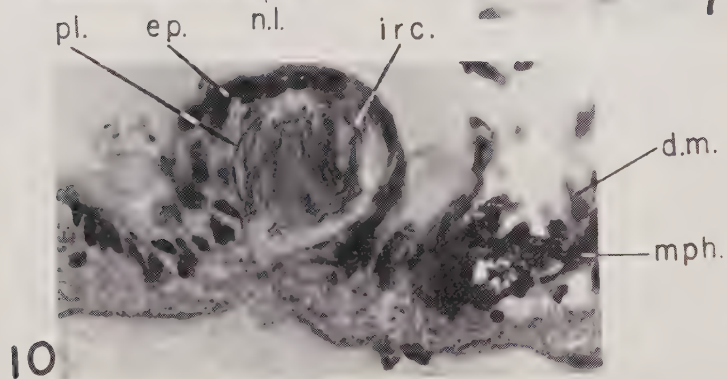
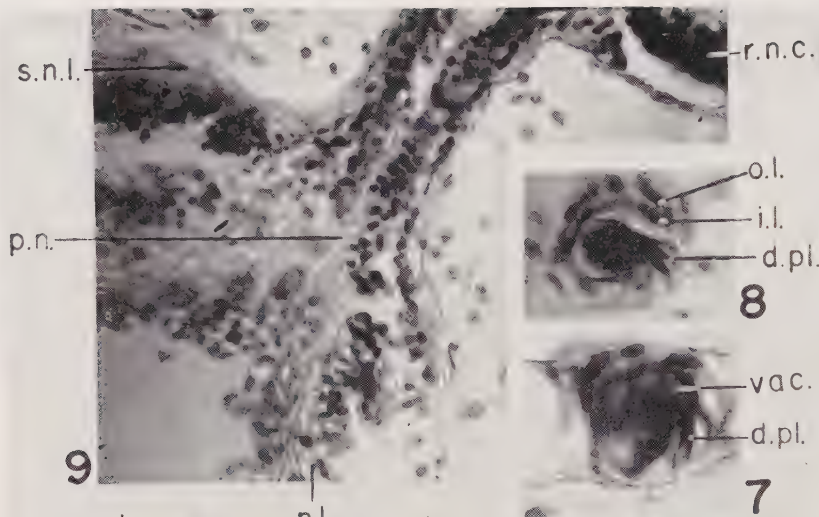
FIGURE 4. Adult photographed in bright light after being in total darkness. Note the white pattern on the interambulacral region of the test. On the left it is becoming broken up by the dispersion of melanin.

FIGURE 5. A photomicrograph of a horizontal section through a cluster of iridophores forming one of the "blue lines" on the test of an individual measuring 13 mm. across the ambitus. *The unlabeled line should read pl.* Fixed, Bouin's fluid; stained, Mallory's triple stain. x approx. 330.

FIGURE 6. Photomicrograph of a section showing an early stage in the differentiation of iridophores, from the interambulacral region of the test of the urchin shown in Fig. 1. Fixed, Bouin's fluid; stained, Delafield's haematoxylin and eosin.

c.ep.	epithelium covering iridophore.
ir.c.	large cell differentiating into iridophore.
mph.	melanophore.
pl.	plate of iridophore.
pst.	peristome.





nerve cord (r.n.c., Fig. 9) were differentiated and supplied parts of the interambulacral areas, by no means all of these areas were supplied, and indeed most of the iridophores appeared to be without any nerve supply (Figs. 6, 7, 8).

This distribution of nerves has some significance in relation to the function of the iridophores (see below) for it makes the suggestion that they function as photoreceptors for the spine reflex (which appears in the very young forms) even more unlikely.

REACTIONS TO SHADING

The sensitivity of the *Diademas* to changes in light intensity has been reported several times (Sarasin and Sarasin, 1887; von Uexküll, 1897, 1900; Dahlgren, 1916; Mortensen, 1940; Millott, 1950). The reaction to shading in particular has been extensively studied and will form the subject of a separate account. It usually appears as a general defensive reaction in which the spines converge towards the shadow, the attached podia shorten so as to pull the test to the substratum, and the unattached tube feet, including the aboral ones specialised for respiration, and the pedicellariae are shortened or flexed quickly towards the substratum. The response is most variable in the case of the

Diadema antillarum

FIGURES 7, 8. Photomicrographs showing successive stages in the differentiation of iridophores from sections through the interambulacral region of the test of the specimen shown in Fig. 1. Fixed and stained as for Fig. 6. Compare with Figs. 10 and 11, and note the absence of the superficial nerve layer.

FIGURE 9. Photomicrograph of a section from the same series as the last, showing the emergence of an interambulacral nerve and the origin of the superficial and podial nerves.

FIGURES 10, 11. Photomicrographs of iridophores and the accompanying melanophores from sections of an urchin measuring 13 mm. across the ambitus. Fixed, Bouin's fluid; stained, Masson's method for the Argentaffine reaction, counterstained in Mallory's triple stain. $\times$ approx. 330. Note conspicuous superficial nerve layer, and melanophores ruptured by the action of the fixative, discharging melanin to the exterior.

d.m.	melanin being discharged from melanophore.
d.pl.	developing plate of iridophore.
ep.	2-layered epithelium covering iridophore.
f.	fibrillar appearance in iridophore.
i.l.	inner layer.
irc.	iridophore.
mph.	melanophore.
n.l.	superficial nerve layer of tube foot.
o.l.	outer layer.
pl.	plate of iridophore.
p.n.	nerve to tube foot.
r.n.c.	radial nerve cord.
s.n.l.	superficial nerve layer.
vac.	vacuole.

pedicellariae. Sometimes only the head is flexed with a snapping movement of the jaws and at others, an indeterminate swaying of the whole organ ensues. Nothing is known of the response of young forms nor of when the reactions first appear. Regrettably it has been possible to study the reactions of only one very young specimen, but as they were clearly defined, it is considered pertinent to record them.

The individual shown in Fig. 1, when in full daylight, responded to a shadow cast on the surface of the test or to the extinguishing of an overhead 40 watt tungsten filament lamp by reactions on the part of the spines, tube feet and pedicellariae. These reactions are mainly the same as those of the adults outlined above. It is clear, therefore, that they must appear very early in life.

However, there were a few differences worthy of note. In the first place the spine movements, unlike those of adult forms, were feeble and directionally indeterminate, spines moving sometimes towards and at other times away from shadows. The response of the unattached tube feet resembled those of the adult and were, by contrast, directionally determinate, since they always flexed actively towards the substratum. The pedicellariae behaved as in the adults. So far as the regularity, constancy of direction and vigor of the response is concerned, there is clearly a gradation as follows: aboral tube feet (gills) > suckered tube feet > pedicellariae > spines.

It is noteworthy that the degree of responsiveness after a sojourn in total darkness follows the same sequence. Thus after being kept in total darkness for 4 hours at laboratory temperature and then transferred to a dish beneath a 40 watt tungsten filament lamp, the very young form showed no reaction to shading or to diminished intensity of illumination for 12.5 minutes. At this point the response of the tube feet appeared, followed, after 5 minutes, by a very slight response of the spines.

Although the data is as yet insufficient to warrant advancing an explanation, it is tempting to speculate that the absence of a well coordinated response on the part of the spines is related to the incomplete state of the superficial nervous system. As already mentioned, so far as can be ascertained from the preparations available, the superficial nerve layer is feebly developed or absent over large areas of the interambulacra. The nerve ring at the bases of the spines is present, however. Since observations were confined to the large interambulacral spines, which when fully developed are connected to the radial nerve strands by elements in the superficial nerve layer and ambula-

cral nerves, their indeterminate and uncoordinated movement is perhaps only to be expected.

In contrast, the podial nerves (p.n., Fig. 9) are well developed, a fact which agrees well with the observed regular and well-defined responses of the tube feet. The fact that the iridophores are few and imperfectly formed may also be significant in this connection, for as suggested by Millott (1953a), these organs, though appearing relatively insensitive to changes in light intensity themselves, may serve to reflect light on to more sensitive portions of the surface (e.g., the ambulacra and spine bases), thereby enhancing sensitivity and the capacity for directional responses.

SUMMARY

1. The occurrence in Jamaica of the young forms of *D. antillarum* is described and the related environmental conditions reviewed.
2. Their color is described and its limited significance as a specific character is discussed.
3. The iridophores, their development, relation to the color change and species characteristics are outlined.
4. The reactions of the very young forms to shading are described and compared with those of older forms.

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SPONGES FROM THE GULF OF MEXICO¹

M. W. DE LAUBENFELS

Department of Zoology, Oregon State College

ABSTRACT

In 1948, a collection of sponges was made by the Marine Laboratory of the University of Miami in the eastern Gulf of Mexico. Twenty-two stations were studied, at depths from 6 to 20 meters, in the area between Dry Tortugas and the northeastern part of the Gulf. The collection comprises 52 species in 41 genera, all within the class Demospongia. Of these, 11 species are new: *Myrmekioderma styx*, *Thalyseurypon vasi-formis*, *Dictyociona adioristica*, *Echinostylinos unguiferus*, *Axinella polycapella*, *Homaxinella waltonsmithi*, *Prianos tierneyi*, *Spirastrella coccinopsis*, *Prostylissa spongia*, *Scolopes megastra*, and *Unimia trisphaera*. The new name *Neamphius* is provided to replace the preoccupied generic name *Amphius*. The new genus *Unimia* is described, with *U. trisphaera* n.sp. as type species. The genus *Darwinella* is removed from the Aplysillidae to the Darwinellidae. *Xestospongia calyx* (Schmidt) and *X. halichondrioides* (Wilson) are synonymous with *X. muta* (Schmidt). *Tenacia micropunctata* Burton (not collected in the Gulf), incorrectly transferred earlier to *Thalyseurypon*, should be placed in the genus *Eurypon*. It is suggested that: *Dictyociona clathrata* and *D. terraenovae* (neither collected in the Gulf) be transferred to the genus *Thalysias*; the order Halichondrina be dropped and most or all of its families removed to the Poecilosclerina; the genus *Paracordyla* be dropped in synonymy to *Scolopes*; *Stelletta tuberosa* Hentschel (not collected in the Gulf) receive the new name *Myriastrea hent-scheli*. Additional description is provided for a number of species. An analysis of the sponge collection by stations is included.

A collection of sponges was made in the autumn of 1948 by the staff of the Marine Laboratory of the University of Miami.² Especial mention should be made of the field work of J. Q. Tierney and Charles Dawson in amassing and preserving this collection. Where notes as to color in life are available, the reference is to this work.

The area from which the specimens were collected is at the east end of the Gulf of Mexico, just west of the peninsula of Florida, and extends from the northwestern portion of the State of Florida southward to the Dry Tortugas. Within this area 22 stations were studied, at depths from 6 to 20 meters, but chiefly between 11 and 15 meters. Professional sponge divers were employed to collect at each station as nearly as possible a complete selection of the fauna and flora there present.

This study was made in behalf of the Florida State Board of Con-

¹ Contribution No. 85 from the Marine Laboratory, University of Miami.

² Specimens in the museum of this institution are denoted by numbers preceded by the designation ML.

servation as a result of the condition of the commercial sponge industry. In 1939-1940, commercial sponges were swept by an epidemic which reduced them to approximately 5 percent of their previous numbers. After 1940, the commercial fishermen collected the survivors of the epidemic so assiduously that by 1948 very few remained. The 22 stations here treated would normally have yielded, prior to 1939, very numerous specimens of *Spongia* and *Hippiospongia*. In 1948, on the contrary, most of these stations yielded no specimens of these, the commercial genera; and no station yielded large, profitable numbers of marketable sponges. The present article thus is concerned chiefly with noncommercial sponges.

The collection includes 52 species, in 41 genera. Of these, one genus and 11 species are here treated as new. None are of the class Calcispongia, probably because the (usually small) calcareous sponges were overlooked by the divers; none are of the class Hyalospongia, because these occur only in deep water, in the Gulf of Mexico chiefly at depths greater than 500 meters. Thus the entire collection is within the class Demospongia.

Order KERATOSA (or KERATOSIDA) Bowerbank

Family SPONGIIDAE Gray

Genus *Spongia* Linné

Spongia zimocca Schmidt subspecies *barbara* Duch. Mich.

This is the well-known commercial variety known as the "yellow" sponge. It was certainly taken at station 21, 6.5 meters depth, 27 October 1948 (ML 4:183). If, as the records indicate, not one was found at any of the other 21 stations, this is evidence of the drastic extent to which the sponge disease epidemic, followed by intensive collecting, had depleted the area.

Spongia graminea Hyatt

This is the well-known commercial variety called the "grass" sponge. It too was certainly taken at station 21, 8 meters depth, 27 October 1948 (ML 4:138 and ML 4:181). These are both poor specimens of a variety which at best is of inferior commercial quality.

Spongia sp. (?)

Notes indicate that at stations 6 and 13 there were taken "wire" sponges. These are not now represented by specimens. Wire sponges may be of several species; the term is vernacular, referring to coarse, inferior quality of skeleton.

Genus *Hippiospongia* de Laubenfels*Hippiospongia lachne* de Laubenfels

This is the well-known commercial variety called the "sheepswool" sponge. It is represented in the collection by ML 4:139, taken at station 22, depth 14.5 meters, 28 October 1948; and by ML 4:242, taken at station 18, depth 14.5 meters, 11 October 1948. It may be observed that the collecting was done by a man accustomed to diving for commercial sponges, and that such a man would be most familiar with "sheepswools" and most alert to find any of this variety that might be present.

Hippiospongia gossypina (Duch. Mich.) de Laubenfels

This is the well-known commercial variety called the "velvet" sponge. It is represented in the collection by ML 4:182, taken at station 22, depth 14.5 meters, 28 October 1942.

Genus *Aulena* Lendenfeld*Aulena columbia* de Laubenfels

This is a little-known genus and only the third record for the species; therefore, it may here be described in some detail.

It is represented in the collection by ML 4:147 (USNM 23392)³, taken at station 20, depth 12.5 meters, 26 October 1948.

It is a mass, chiefly amorphous but somewhat lobate, 11 cm. high, and 12 by 14 cm. laterally. The color of the exterior is chiefly pale drab, but some portions are darker, almost black. The interior is altogether pale drab. The consistency is spongy.

The surface must be described as conulose. Other specimens of this genus have possessed instead surfaces tuberculate, or even villous. Yet to the author this specimen had immediately the appearance of an *Aulena*. This is attributable, in part, to the oscules (3 to 6 mm. in original diameter), which close by iris-type membranes. This is a marked difference from the oscules of *Spongia* and *Hippiospongia* which *Aulena* otherwise resembles. The very numerous pores are microscopic, probably all under 60 microns in diameter.

The ectosome is a very thin organic dermis, about 10 microns thick, over fairly extensive subdermal cavities. The endosome has the unique structure of *Aulena*. The inhalant and exhalant canals (prosochetes and apochetes) are never small, but are all so large that the rest of the tissue is reduced to thin sheets about 30 microns thick. In these the flagellate chambers appear like holes, 30 microns in diameter.

³ Refers to U. S. National Museum catalog number.

The skeleton consists of a fibrous reticulation. The fibers are extremely like those of *Spongia*, with clear secondaries and debris-filled, rather uncommon primaries (ascending fibers), but in *Aulena* they are some 60 microns in diameter, as compared to 20 microns in *Spongia*. The meshes are also correspondingly coarse. It may be that many of the commercial sponges of the poor quality termed "wire" sponges were *Aulenas*. Doubtless other genera were also lumped into this category.

The species *columbia* was described by de Laubenfels (1936, page 13) from two specimens dredged on 25 and 26 June 1932 near Loggerhead Key and thus near the location of this third specimen.

Genus *Ircinia* Nardo

Ircinia fasciculata (Pallas) de Laubenfels

This is often known colloquially as the "stinker" sponge, but all species of *Ircinia* have the identical sulfurous odor and also the peculiar microscopic filaments which render their flesh the toughest, most leathery of all sponges. This, often incorrectly known as *variabilis*, is the brown, amorphous and lobate species, with dark oscules and the smallest conules.

It is represented in the collection by ML 4:050, taken at station 4, depth 14.5 meters, 25 September 1948; and ML 4:204, taken at station 19, depth 18 meters, 24 October 1948. Notes indicate that it was also taken at stations 13, 14, 20 and 22, these four not now being represented by specimens.

Ircinia campana (Lamarck) de Laubenfels

This is the bell- or vase-shaped *Ircinia*, more or less reddish, with medium-sized conules (see: de Laubenfels, 1936, plate 8, opposite page 20).

It is represented in the collection by ML 4:062, taken at station 10, depth 12.5 meters, 30 September 1948; and ML 4:194, taken at station 8, depth 14 meters, 29 September 1948. Notes indicate that it was also taken at stations 5, 6, 7, 11, 13, 14, 17, 19, 20, and 21, these ten not now being represented by specimens.

Ircinia strobilina (Lamarck) de Laubenfels

This is the cake-shaped *Ircinia*, dark grey to black, with the coarsest conules. It is called "loggerhead" in the Bahamas, but is not identical with sponges elsewhere called by that name.

It is represented in the collection by ML 4:066, taken at station 11, depth 11 meters, 1 October 1948; and by ML 4:243, taken at

station 10, depth 12.5 meters, 30 September 1948. Notes indicate that it was also taken at stations 6, 8, 13, 15, 16, 17 and 19, but these seven are not now represented by specimens.

Obviously sponges of the genus *Ircinia* withstood the sponge epidemic excellently.

Genus *Verongia* Bowerbank

Verongia fistularis (Pallas) de Laubenfels

This is the tubular, bright yellow *Verongia* that turns black and hard upon dying. It is represented in the collection by ML 4:070, taken at station 16, depth 22 meters, 3 October 1948.

Verongia aurea (Hyatt) de Laubenfels

This is much like the preceding, but not hollow; the two may really be conspecific. It is represented in the collection by ML 4:192, taken at station 19, depth 18 meters, 24 October 1948.

Verongia lacunosa (Lamarck) de Laubenfels

This is the tubular *Verongia* with deep horizontal-convoluted folds on its surface, not as yellow in life, nor quite as black upon preservation as the preceding. It has long been known, incorrectly, as *Verongia archeri*. It is represented in the collection by ML 4:195, taken at station 16, depth 20 meters, 3 October 1948.

Verongia longissima (Carter) de Laubenfels

This is the long, thin, ramose *Verongia*, not bright yellow in life nor quite black after death. It is represented in the collection by ML 4:149, taken at station 8, depth 14 meters, 29 September 1948. Notes indicate that it was also taken at stations 14, 19, and 20, but these three are not now represented by specimens.

Family DYSIDEIDAE Gray

Genus *Dysidea* Johnston

Dysidea fragilis (Montagu) Johnston

This is the common grey or lavender *Dysidea*, described in detail by de Laubenfels (1936, July 27; 1950, May 22). It is represented in the collection by ML 4:205, taken at station 10, depth 12.5 meters, 30 September 1948. Notes indicate that it was also taken at station 5; this is not now represented by a specimen.

Dysidea crawshayi de Laubenfels

This is the orange colored, conulose sponge that may eventually need a genus of its own, because of its peculiar chemical properties,

concerning especially the elements fluorine and nickel. It was first described by de Laubenfels (1936, page 28), and it was later described in more detail by de Laubenfels (1950, page 26). It is represented in the collection by ML 4:226 (USNM 23393), taken at station 7, depth 14 meters, 28 September 1948.

Genus *Ianthella* Gray

Ianthella ardis de Laubenfels

This interesting species was first described from the Dry Tortugas area by de Laubenfels (1936, page 31), where it was erroneously identified as being *Ianthella basta*. It was described in detail and given the name *ardis*, by de Laubenfels (1950, page 31). It is massive, conulose, more-or-less greenish in life, turning black after dying. There are cells inside the hollow fibers.

It is represented in the collection by ML 4:199, taken at station 14, depth 12 meters, 2 October 1948, and by ML 4:241, taken at station 16, depth 20 meters, 3 October 1948.

Family APLYSILLIDAE Vosmaer

Genus *Aplysilla* F. E. Schulze

Aplysilla sulfurea F. E. Schulze

The species *sulfurea* is bright yellow in life; so was the specimen now under discussion. However, *sulfurea* usually turns black after dying and this specimen has turned dull red. The species *glacialis* has also been reported from the West Indian region (de Laubenfels, 1950, page 36) and is rosy red in life, but it fades upon preservation. The present specimen, except for color, might be either *glacialis* or *sulfurea*, but appears more like *sulfurea*. The identification is tentative.

It is represented in the collection by ML 4:212 (USNM 23394), taken at station 4, depth 14.5 meters, 25 September 1948.

Family DARWINELLIDAE Vosmaer

Genus *Darwinella* Müller

Darwinella mülleri Max Schulze

This genus is so rare and interesting that this discovery of a specimen of it warrants description.

It is represented in the collection by ML 4:203 (USNM 23395), taken at station 20, depth 12.5 meters, 26 October 1948.

It is a ramose sponge, reaching a height of 12 cm. The numerous branches (more than 20) are about 1 cm. in diameter but quite irregular in shape and size; many are hollow. Field notes indicate that the color in life was "reddish tan" and that portions of the sponge

appeared to be diseased. The preserved sponge is pale drab. The consistency is softly spongy, easily torn.

The surface is conulose, each conule little more than a protruding fiber-end; they are 0.5 mm. high and 1 to 2 mm. apart. There is an organic dermis about 10 microns thick. The pores are closed. The oscules may be represented by the 2 to 7 mm. diameter apertures at the apices of the hollow branches. The flagellate chambers are conspicuous, 50 to 60 microns in diameter.

The skeleton includes a basic mass of dendritic fibers but with many anastomoses between them, so that a definite reticulation results. The larger fibers contain scattered bits of foreign debris; some grains of sand in the fibers are so large that the spongin merely ties them together.

There are numerous spicules made of spongin, as characteristic of the genus *Darwinella*. These are nearly always triaxons with rays about 15 by 500 to 600 microns in dimension, but a few of them are tetraxons, instead.

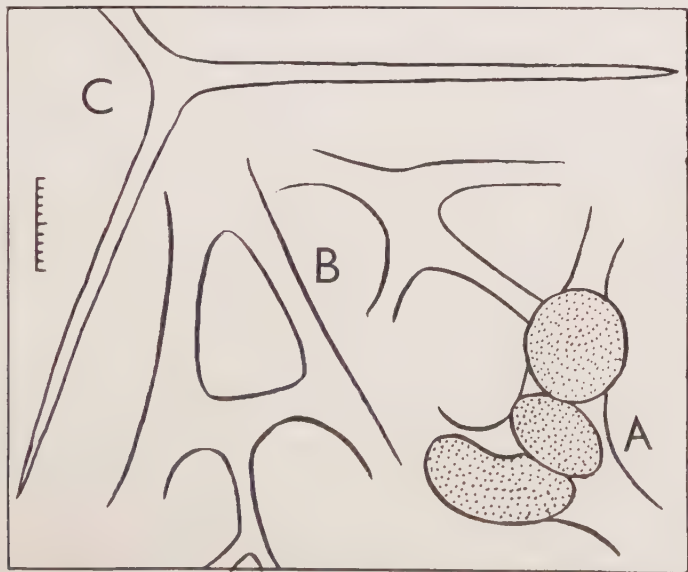


FIGURE 1. *Darwinella mülleri*. A: A small portion of a fiber that contains foreign debris. B: Two portions of the commoner clear fiber, illustrating size and pattern. C: A portion of one of the spicules made of spongin. These are camera lucida drawings, matching the enclosed scale, which shows 100 microns divided into 10-micron units.

This species was described by Max Schulze (1865, page 5) from the Mediterranean region. It was later recorded from Australia by Carter (1885, page 202), then from Bermuda by de Laubenfels (1950, page 38), in each case noted as rare. A report is here made for the first time of the discovery of the species as a thin crust on a mangrove root at Garden Cove, Key Largo, Florida, 9 July 1952. As more specimens accumulate, it may prove necessary to divide the genus into several species.

Darwinella has been put, always with reservations, in the same family with *Aplysilla*. This family was named by Vosmaer in Bronn's "Thierreich." In some of the printings (made in 1886), he called it Darwinellidae, because *Darwinella* was the oldest genus in the family. In other printings of the same reference (made in 1883), he had it instead as Aplysillidae. This was defended by de Laubenfels (1948, page 163) because of the fact that *Darwinella* might need removal from the family. The time has now come for such removal. The present specimen is the most ample yet found and reveals two significant characteristics: the tendency to incorporate foreign debris in some fibers, and the tendencies for fibers to anastomose to yield reticulate skeletons. Therefore, we need to recognize a distinctive family for the genus. The name may, however, be ascribed to Vosmaer as of 1886, but amended to exclude all the other genera that were placed in Aplysillidae by de Laubenfels (1948, page 163). Thus the Aplysillidae now includes only *Aplysilla*, *Chelonaplysilla*, *Pleraplysilla*, and *Psammaplysilla*.

The family Aplysillidae is characterized thus: Keratosa with fibers of concentrically laminated spongin; these fibers are dendritic, with no anastomoses, or at most an occasional apparently accidental junction. They do not contain foreign debris. The flagellate chambers tend to be very large, often about 50 to 60 microns in diameter.

The family Darwinellidae may be characterized thus: Keratosa with fibers of concentrically laminated spongin; these fibers are chiefly dendritic, but do exhibit fairly frequent anastomoses, yielding reticulations. They sometimes contain foreign debris. There are also present spicules made of spongin, often triactinellid in shape, but sometimes tetractinellid or even polyactinellid.

Order HAPLOSCLERINA (or HAPLOSCLERIDA) Topsent

Family HALICLONIDAE de Laubenfels

Genus *Haliclona* Grant*Haliclona rubens* (Pallas) de Laubenfels

This common, red, ramose *Haliclona* was redescribed in detail by de Laubenfels (1936, page 40). It is represented in the collection by ML 4:196, taken at station 13, depth 19 meters, 2 October 1948. Notes indicate that it was also taken at station 13; this is not now represented by a specimen.

Haliclona viridis (Duch. Mich.) de Laubenfels

This common, incrusting, massive or ramose green *Haliclona* was redescribed in detail by de Laubenfels (1936, page 42). It is represented in the collection by ML 4:151, taken at station 8, depth 14 meters, 29 September 1948, and ML 4:213 (USNM 23396), taken at station 21, depth 6.5 meters, 27 October 1948. It is probably also represented by small specimens growing on the surfaces of large specimens of other genera. *Haliclona viridis* often grows on other sponges.

Genus *Neopetrosia* de Laubenfels*Neopetrosia longleyi* de Laubenfels

This is an abundant West Indian species, brittle and internally pale, externally ranging from drab, to yellow green, to olive green. It is repent and ramose, with conspicuous oscules. It was redescribed in detail by de Laubenfels (1936, page 44). It is represented in the collection by ML 4:078, taken at station 6, depth 12 meters, 27 September 1948.

Genus *Xestospongia* de Laubenfels*Xestospongia muta* (Schmidt) de Laubenfels

This is a species that warrants redescription and reconsideration. It is represented in the collection by ML 4:223 (USNM 23397), taken at station 13, depth 19 meters, 2 October 1948.

According to field notes, the specimen was a cup or vase 20 cm. high and 15 cm. in diameter. Portions of this occur in the collection, preserved in alcohol. The bulk of the specimen appears to be missing but may later be found. The walls of the vase were 4 cm. thick. The central concavity was described as being only 6 cm. deep. The color in life was given in the field notes as externally pink, internally yellow. The alcoholic specimen is dark walnut brown, slightly paler internally

than externally. The consistency is firm, somewhat brittle, as characteristic of *Xestospongia*.

The surface is uneven but not hispid. The pores cannot now be perceived. Oscules were represented, according to field notes, by a number of small openings on the bottom of the concavity. There is no dermal specialization. The interior is packed with spicules, rather outlining chambers and canals than forming elongate tracts. The spicules are diactines, varying from oxeas to strongyles, sizes about 15 by 300 microns.

Schmidt (1870, page 44) described sponges as *Schmidtia calyx* and *Schmidtia muta*. The former was vasiform with thinner spicules. The latter was massive, with thicker spicules. The descriptions are tantalizingly brief, but the proper genus is clearly *Xestospongia*, as observed by de Laubenfels (1950, page 51). Wilson (1902, page 389) described a similar massive sponge from Puerto Rico as *Petrosia halichondrioides*. It was set apart by its dark brown color in preservative. It was transferred to *Xestospongia* by de Laubenfels (1950, page 51).

In Bermuda, there was a large, macerated vasiform sponge, described by de Laubenfels (1950, page 49) as *Xestospongia calyx* (Schmidt).

The Gulf of Mexico sponge of the present collection for the first time reveals the color in life. It turns dark brown after death, and therefore it seems evident that *halichondrioides* should fall in synonymy to *muta*. The present sponge has the thicker spicules of *muta* but tends in the direction of the shape of *calyx*. It is here suggested that this variation falls within the normal range of the species, exactly as it does in the genus *Sphaciospongia*. Certainly in the latter genus, and probably in *Xestospongia*, thick-walled vases may result from an accumulation of foreign debris on a top which originally was only slightly concave. The periphery continues to grow vertically, while growth of the center is inhibited. Therefore, the species *calyx* should also be dropped in synonymy to the species *muta*.

Genus *Dasychalina* Ridley and Dendy

Dasychalina cyathina de Laubenfels

This has been known hitherto only from beachworn, macerated specimens; therefore, a redescription may be appropriate.

This is represented in the collection by ML 4:206 (USNM 23398), taken at station 14, depth 12 meters, 2 October 1948. Notes indicate

that it was also taken at stations 13 and 16; these are not now represented by specimens.

It is a vase 19 cm. high and 10 cm. in diameter, with walls chiefly about 1 cm. thick, but tapering to a fairly sharp upper rim. Many fibers project above the rim, giving it an erect, stiff fringe. The color in alcohol is nearly black. Is this brought about by other sponges that were with it, or by post-mortem alterations of various kinds? No data as to the color in life is available. This is especially regrettable because the species (as already noted) has been known previously only from beachworn specimens. The blackish color is quite unexpected within the genus, is rare in the family, and may well be artificial or post-mortem. The consistency is stiffly spongy.

The surface is conulose, with conules 1 to 2 mm. high, 2 to 4 mm. apart. The pores seem to be closed, but the oscules, or (better) the apopores, opening into the cloaca are 1 to 2 mm. in diameter and about 4 mm. apart, center to center. The ectosome is somewhat fleshy but scarcely, if at all, set off from the micro-cavernous enclosure.

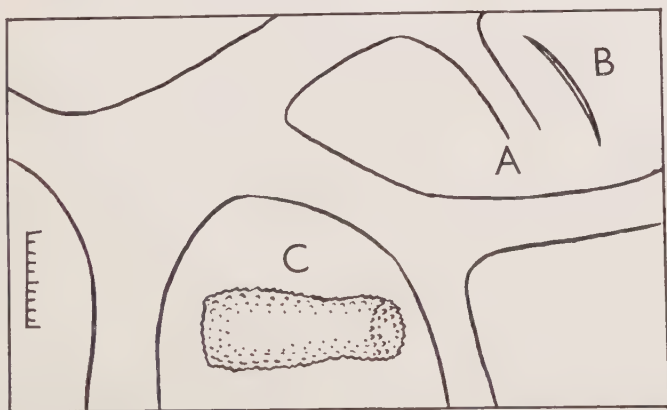


FIGURE 2. *Dasychalina cyathina*. A: Camera lucida drawing of a portion of the fibrous skeleton. B: Camera lucida drawing of one of the spicules. A and B match the enclosed scale which shows 100 microns with 10-micron subdivisions. C: Free-hand sketch of the entire sponge, x 1/9.

The skeleton consists of spongin fibers often 60 microns in diameter, but some are larger, even up to 120 microns, forming an irregular reticulation, with meshes at least 300 microns in diameter. The spicules are oxeas usually 5 by 150 microns; smaller ones are probably developmental. A few are as large as 7 by 200 microns.

These spicules are common both loose in the flesh and also embedded in the fibers—at least seven per cross section of any fiber.

This species was described by de Laubenfels (1936, page 45) from the Dry Tortugas, on the basis of a macerated beachworn specimen. The skeleton of the present specimen is very much like that of the type specimen, even in details.

Family DESMACIDONIDAE Gray

Genus *Iotrochota* Ridley

Iotrochota birotulata Higgin

This is the fairly common West Indian ramose sponge that not only emits a purple exudate, but also is dark purple in life, with a yellow-green surface sheen. It was described at length by de Laubenfels (1936, page 49).

It is represented in the collection by ML 4:207, taken at station 14, depth 12 meters, 2 October 1948. Notes indicate that it was also taken at station 16 but this is not now represented by a specimen.

Genus *Fibulia* Carter

Fibulia massa Carter

Sponges of the genus *Fibulia* are even more chemically irritating than those of the notorious genus *Tedania*. They resemble wet loaves of bread. They were described by de Laubenfels (1936, page 51). The various species of *Fibulia* are separated for differences in the microclere content and are closely inter-related. Probably the commonest species is *nolitangere* Duchassaing and Michelotti. The present specimen, however, has the strongyles, raphides and sigmas which characterize the species *massa*.

It is represented in the collection by ML 4:210 (USNM 23399), taken at station 7, depth 14 meters, 28 September 1948. Notes indicate that a *Fibulia* was also taken at station 8 but this is not now represented by a specimen, and the species therefore cannot be determined.

Genus *Xytopsues* de Laubenfels

Xytopsues griseus (Schmidt) de Laubenfels

A detailed description of this curious sponge was given by de Laubenfels (1950, page 75). The present specimen resembles that from Bermuda in amazing detail, even to being packed with algae, probably of the genus *Jania*. This species is represented in the collection by ML 4:224 (USNM 23424), taken at station 15, depth 17 meters, 3 October 1948.

Family CALLYSPONGIIDAE de Laubenfels

Genus *Callyspongia* Duch. Mich.*Callyspongia vaginalis* (Lamarck) de Laubenfels

This is the abundant, tube-shaped West Indian sponge. It was discussed by de Laubenfels (1936, page 56). The genus *Patuloscula* was also accepted as valid; this is no longer the accepted opinion. It must be dropped in synonymy to *Callyspongia*. The species described on page 56 (loc. cit.) is not *plicifera* but *procumbens*; *plicifera* is characterized by walls that are curiously and conspicuously horizontally folded. *Callyspongia vaginalis* is represented in the present collection by ML 4:185, taken at station 10, depth 12.5 meters, 30 September 1948; and by ML 4:240, taken at station 14, depth 12 meters, 2 October 1948. Notes indicate that two additional specimens were taken at station 14, two at station 16, others at stations 17 and 20.

Order POECILOSCLERINA (or POECILOSCLERIDA) Topsent

Family PHORBASIDAE de Laubenfels

Genus *Myrmekioderma* Ehlers*Myrmekioderma styx* new species

The holotype of this species is USNM 23400. The paratype (a portion of the holotype) is ML 4:211, taken at station 10, depth 12.5 meters, 30 September 1948.

This is an amorphous sponge, exceedingly lumpy, 7 cm. high and 14 cm. in diameter. Field notes indicate that in life it was orange, with a whitish appearance at the surface; this latter is caused by the abundance of spicules there, and in some cases by foreign debris. The consistency is mediocre.

The surface is extremely irregular, but there are hundreds of hemispherical lumps or tubercles, 3 mm. in diameter. These and the color are very characteristic of the genus *Myrmekioderma*. There are several saucer-shaped depressions 12 mm. in diameter. Field notes indicate that these showed many apertures in the freshly collected specimen and may be regarded as pore areas. Some, however, may have been exhalant. There are coarse pits here and there; some of these may represent the oscules, but they appear rather to be the locations from which foreign objects have been removed. The ectosome is an organic dermis, blending into the underlying endosome. The latter is dense but contains many canals about 6 mm. in diameter. There are spicular tracts present, but there is no definite reticulation.

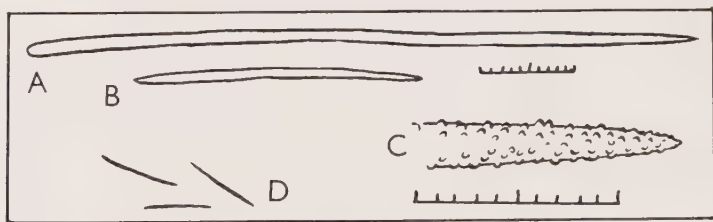


FIGURE 3. *Myrmekioderma styx*. Camera lucida drawings. A: Style. B: Oxea. These match the upper scale, which shows 100 microns divided into 10-micron units. C: One end of the oxea. D: Raphides. C and D match the lower scale, which shows 50 microns subdivided into 5-micron units.

The megascleres are of two sorts. Firstly, there are smooth mon-axons, usually styles, but sometimes approaching oxeote or strongy- lote shape. These are about 12 by 700 microns. Secondly, there are abundant oxeas 10 by 330 microns, covered with minute tubercles; they might be termed acanthoxeas, but are different from the ordinary spicule type so named. The microscleres are raphides or trichodrag- mas, 0.3 by 20 microns; these are especially abundant at the imme- diate surface.

This species is distinctive for the sort of microscleire present, but especially for the grouping of pores in rounded shallow depressions. In other species of the genus, the pores are distributed along the bottoms of the valleys which separate the distinctive convexities of the surface.

Family COELOSPHAERIDAE Hentschel

Genus *Rhizochalina* Schmidt

Rhizochalina hondurasensis (Carter) de Laubenfels

The specimen now under consideration is not typical of the species to which it is assigned; therefore, a description of it is warranted.

This is represented in the collection by ML 4:209 (USMN 23401), taken at station 16, depth 20 meters, 3 October 1948.

It is hemispherical, 11 cm. high and 9 by 20 cm. in lateral measure- ment. It is said to have been brown in life but now it is nearly black. The consistency is stiff and somewhat crumbling, yet the dermis and fibers are tough.

The surface is irregular. The pores, now closed, seem to have been about 100 microns in diameter and abundant. The oscules are repre- sented by thin walled tubes, 3 mm. in diameter. Of these, there is

one per 2 square cm. over most of the sponge's convex surface. These tubes are usually about 20 mm. high. The ectosome is a felted mass of chiefly horizontal spicules and is about 30 microns thick, very dense. The endosome is cavernous; the many spherical cavities (which are about 1 mm. diameter) represent the meshes in a three dimensional reticulation of fibers that are about 100 microns thick. The flesh is thinner than the fibers and chiefly coats them. Thus, there is a very high ratio of cavity to solid or semi-solid substance. It is typical of the genus *Rhizochalina* that the interior should be even more coarsely cavernous, even a single large cavity. That such is not the case for the present specimen may be due to the fact that it is exceptionally old, past maturity.

Family MICROCIONIDAE Hentschel

Genus *Thalyseurypon* de Laubenfels

Thalyseurypon vasiformis new species

The holotype of this species is USNM 23403. The paratype is ML 4:232, taken at station 21, depth 6.5 meters, 27 October 1948.

It is vase-shaped, 14 cm. high, 12 cm. in diameter at the rim. The base of attachment was 5 cm. in diameter. The walls taper from a basal thickness of 3 cm. to a fairly sharp rim. The color of the exterior is very dark drab, almost black; the interior is also very dark drab. Field notes indicate that these were also the colors in life. The consistency is flexible and compressible.

The surface is described in field notes as being "slippery" in life. It is smooth in most places, but coarsely lumpy, with some patches quite villous; the latter appearance may be the result of foreign objects becoming attached to the growing surface. The pores and oscules are not visible to the unaided eye.

The ectosome shows organic specialization only and is not sharply marked off from the endosome. The latter is cavernous, with many fibers that form only a vague reticulation, and are chiefly in confusion. The fibers are often a little more than 200 microns in diameter. They contain spongin but chiefly are packed with spicules.

The skeleton comprises the above mentioned fibers and spicules. The abundant type is a large, smooth tylostyle, often about 11 by 700 microns. Some are as large as 13 by 900 microns. Much smaller ones may be juveniles. These spicules fill the fibers, and some are loose in the flesh. A second type of megasclere is an acanthotylostyle, about 5 by 105 microns; this sort occurs chiefly as echinating the fibers. A

long and careful search was made for microscleres. Three sigmas were finally found, but from so large a volume of sponge that it must be seriously doubted that they are proper to it.

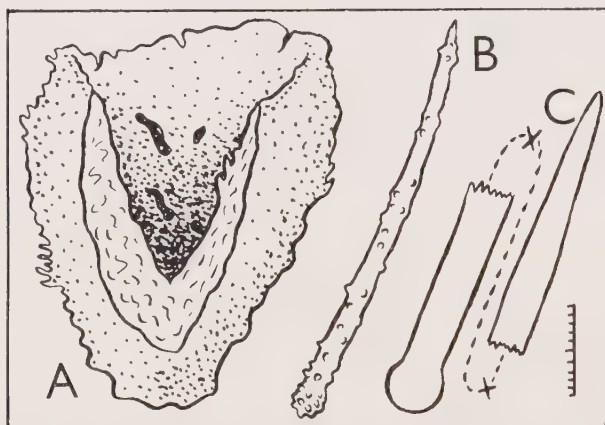


FIGURE 4. *Thalyseurypon vasiiformis*. A: Free-hand sketch of the sponge (with a section cut out), $\times 1/3$. B: Camera lucida drawing of one of the echinating spicules. C: Camera lucida drawing of the head and of the point of one of the tylostyles. The central portion is not shown. B and C match the enclosed scale, which shows 100 microns divided into 10-micron units.

This species, as indicated by the specific name which has been selected, is sharply characterized by its vase-like shape.

In 1936 (page 107), de Laubenfels transferred *Tenacia micropunctata* Burton to *Thalyseurypon*; this was not correct. The species should rather be transferred to the genus *Eurypon*.

Genus *Dictyociona* Topsent

Dictyociona adioristica new species

The holotype of this species is USNM 23403. The paratype is ML 4:214, taken at station 8, depth 14 meters, 29 September 1948.

The specimen appears ramose, but it may have been an encrustation detached in such a manner as to yield this appearance. The greatest measurement is about 20 mm., the thickness, 2 to 5 mm. The color in life was bright red, and the consistency is mediocre.

The surface is velvety smooth, with only very thin organic specialization. The pores and oscules are closed. There are vague tracts of relatively large tylostyles with spines only on their heads; these mega-

scleres are about 15 to 330 microns. The tracts are echinated by smaller acanthotylostyles, 8 by 82 microns in dimensions. Intermediates occur. The microscleres include abundant palmate isochelas 12 microns long. Toxas are also to be expected, but search has not so far revealed them.

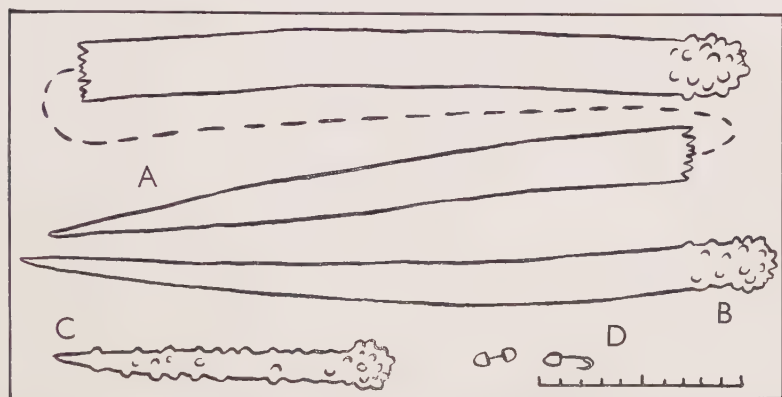


FIGURE 5. *Dictyociona adioristica*. Camera lucida drawings. A: Principal megasclere type, in two installments; the entire tylostyle shows. B: Intermediate type. C: Echinating acanthotylostyle. D: Two palmate isochelas. All these correspond to the enclosed scale, which shows 50 microns divided into 5-micron units.

The species *adioristica* is much like many others of the genus. In the following outline, however, there are cited only some of the respects wherein *adioristica* differs from the other species to which it is compared. All the species now in *Dictyociona* are considered.

D. acanthotoxa (Ireland) has megascleres half as thick but twice as long. It not only has toxas, but these are peculiarly spined.

D. asodes (California) is distinctly yellow in color, and some of its chelas are only 3 microns long.

D. clathrata (Australia) is not a proper *Dictyociona*, and should be transferred to *Thalysias*.

D. discreta (Chile and Argentina; the genotype) not only has toxas (a small difference) but has some special dermal smooth tylostyles.

D. ditoxa (Ireland) has no spicules that are obviously echinating, and it has two kinds of toxas.

D. heterotoxa (Arctic) also has these two kinds of toxas, and, like *D. acanthotoxa*, has very long, very thin megascleres.

D. microchela (Ireland) lacks obvious echinating spicules and has very small chelas.

D. oxneri (Azores) has a second type of chela, very peculiar.

D. pyramidalis (Australia) has peculiar tornotes.

D. tenuissima (Ireland) has extremely large megascleres (21 by 1500 microns) and very long toxas (550 microns).

D. terraenovae (New Zealand) should be transferred to *Thalysias*.

Family OPHLITASPONGIIDAE de Laubenfels

Genus *Mycale* Gray

Mycale angulosa (Duch. Mich.) de Laubenfels

This common species was redescribed in detail by de Laubenfels (1936, page 114). The color varies with ecologic placement from grey to dark red. The convenient recognition mark is the extremely cavernous structure, like a froth of bubbles often nearly a centimeter in diameter. The spiculation of tylostyles with palmate anisochelas is distinctive.

It is represented in the collection by ML 4:197, taken at station 13, depth 19 meters, 2 October 1948; and by ML 4:239, taken at station 11, depth 11 meters, 1 October 1948. Notes indicate that it was also taken at stations 8 and 16; these are not now represented by specimens.

Genus *Echinostylinos* Topsent

Echinostylinos unguiferus new species

The holotype of this species is USNM 23404. The paratype is ML 4:215. This species was taken at station 10, depth 12.5 meters, 30 September 1948.

This sponge may be described as ramose, but the branches anastomose and are much more irregular than is true of most sponges so designated. The whole reaches a height of about 8 cm. and nearly as great a diameter. The basis of attachment is about 2 cm. in diameter. The branches are very irregular and lumpy, but they are under 1 cm. in greatest diameter. The sponge was bright red in life. Its consistency is mediocre.

The surface is velvety smooth, with only very thin organic specialization. The pores and oscules are closed. The endosome is full of exceptionally large flagellate chambers, often as much as 85 microns in diameter.

The skeleton comprises numerous smooth styles usually 13 by 100 microns to 12 by 145 microns. These make up tracts so vague that it

is not profitable to assign measurements to them. A second sort of megasclere is a smooth tylostyle, 5 by 90 microns. Spicules of this sort are scattered between the vague tracts of styles and might even be regarded as echinating them. They also abound at the surface, where they are often placed with their points outward. The fairly abundant microscleres may be described as arcuate chelas, but they have exceptionally sharp-pointed clads and are emphatically unguiferate. There is a larger size range, 20 microns in chord measurement, and a smaller category 10 microns in chord measurement. The latter may be chelas with reduced clads, or, on the other hand, they may be described as sigmas.

This species is unique within the genus for the unguiferate nature of its chelas, hence the specific name.

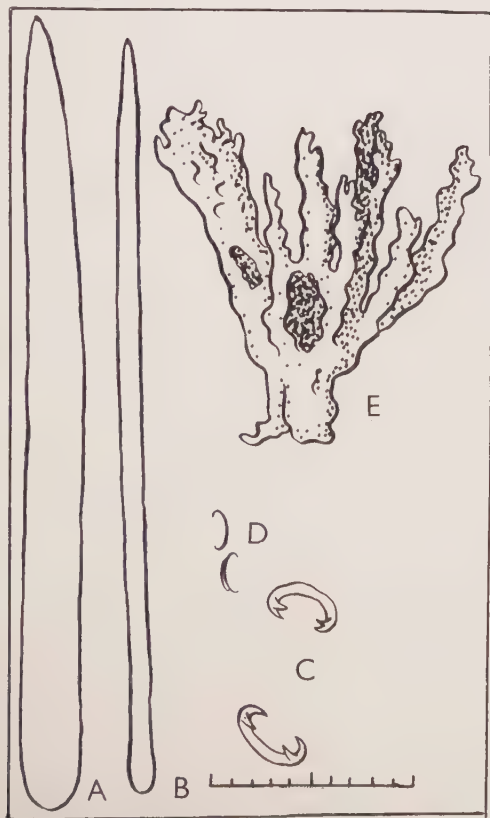


FIGURE 6. *Echinostylinos unguiferus*. A: Principal style. B: Supplementary tylostyle. C: Unguiferate arcuate isochela. D: Sigmas or reduced chelas. A, B, C, and D are camera lucida drawings, and match the enclosed scale, which shows 50 microns divided into 5-micron units. E: Free hand sketch of a portion of the sponge, $\times 1/3$.

Order (?) HALICHONDRINA Vosmaer

This order is not at all firmly established, but rather is open to severe criticism. It seems evident that many of its members are Ophlitaspongiidae merely deprived of microscleres; this shows affinity to the order Poecilosclerina. On the other hand, the Halichondridae, type family of the order, approach the Haliclonidae so closely that separation in the field is sometimes impossible. Yet *Haliclona* is in the order Haposclerina. These three orders blend together, with connecting intermediates of such complexity that at least a three dimensional diagram would be necessary to represent the relationships. It is here suggested that the order Halichondrina should be dropped and that most or all of its families be merged with those of the Poecilosclerina.

Family AXINELLIDAE Ridley and Dendy

Genus *Axinella* Schmidt*Axinella polycapella* new species

The holotype of this species is USNM 23405. The paratype (a portion of the holotype) is ML 4:202, taken at station 9, depth 13 meters, 29 September 1948. Notes indicate that it was also taken at stations 1, 4, 5, 6, 10, 11, 13, 18, 19, 20, 21 and 23; these twelve are not now represented by specimens. This is obviously an exceptionally abundant sponge in the eastern Gulf of Mexico, or else one that divers were especially likely to notice and be inclined to collect.

It is pronouncedly ramose. The type specimen was 60 cm. tall, and field notes indicate that yet taller ones occur, up at least to 75 cm. The branches are each about 1.5 cm. in diameter. The color is said to be bright red or orange-red in life. The consistency is stiffly spongy.

The surface is punctiform and hispid so that it is like velvet. The pores must have been about 300 microns in diameter, and situated one per square mm. of surface. The oscules are 1 to 2 mm. in diameter, about 1 cm. apart, and each is typically surrounded by a stellate pattern of radiating grooves. The dermis is protoplasmic, thin, and easily lost. The endosome contains a dense, flexible tough axis, whose diameter is about one third of that of the entire branch; in it the fibers run lengthwise. In the extra-axial region, there are plumose tracts perpendicular to the axis, and to the surface of the sponge. The tracts, and especially the fibers of the axis, contain spongin.

The spiculation of this sponge consists almost entirely of oxeas, about 7 by 234 to 11 by 215 microns. A few styles can be found, however, with dimensions about 7 by 178 microns.

Schmidt (1862, page 62) described *Axinella polypoides* from the Mediterranean. In 1870 (page 61), having specimens from the Gulf of Mexico (which must have been of the species now under discussion), he identified them, too, as being *polypoides*. There is certainly close relationship, but the Mediterranean sponge is yellow, where the American one is red; the Mediterranean form has abundant styles whereas these spicules are rare in the sponge from the Gulf of Mexico. Therefore, albeit with some hesitation, the latter is here treated as being a distinct species.

The following quotation concerning *Axinella polycapella* is from a report by J. Q. Tierney. He says:

"The commercial sponge divers of the Gulf of Mexico use these sponges as scouring pads; they are used to clean the glass face plates and metal parts of the diving helmet, and are rubbed over the inner surface of the face plate before the diver descends in order to prevent fogging of the glass by moisture. The author has dived in gear so treated, and no fogging at all was noticed. The spongers also use the sponges to polish bright work on board their vessels, and even use them as toothbrushes. Except for a slight 'fishy' taste, such an experience is not unpleasant, and the sponge removes stains from the teeth. Copper and bronze are quickly brought to a shining lustre when polished with this sponge."

Genus *Homaxinella* Topsent

Homaxinella rudis (Verrill) de Laubenfels

The specimen now under consideration is not typical of the species to which it is assigned; therefore, a description of it is warranted.

It is represented in the collection by ML 4:060 (USNM 23406), taken at station 4, depth 14.5 meters, 25 September 1948.

This is a ramose sponge with only a few (dichotomous) branchings. It reaches a height of 30 cm. and the branches are about 1.3 cm. in diameter. The color in alcohol is a pale yellowish-drab. No information as to appearance in life is available. The consistency is firm but flexible.

The surface is roughly punctiform; doubtless the pores were at the bottoms of the myriad little pits. The locations of the otherwise invisible oscules are revealed by occasional stellate patterns of radiating grooves. There is a very thin dermis, mostly lost. The endosome in-

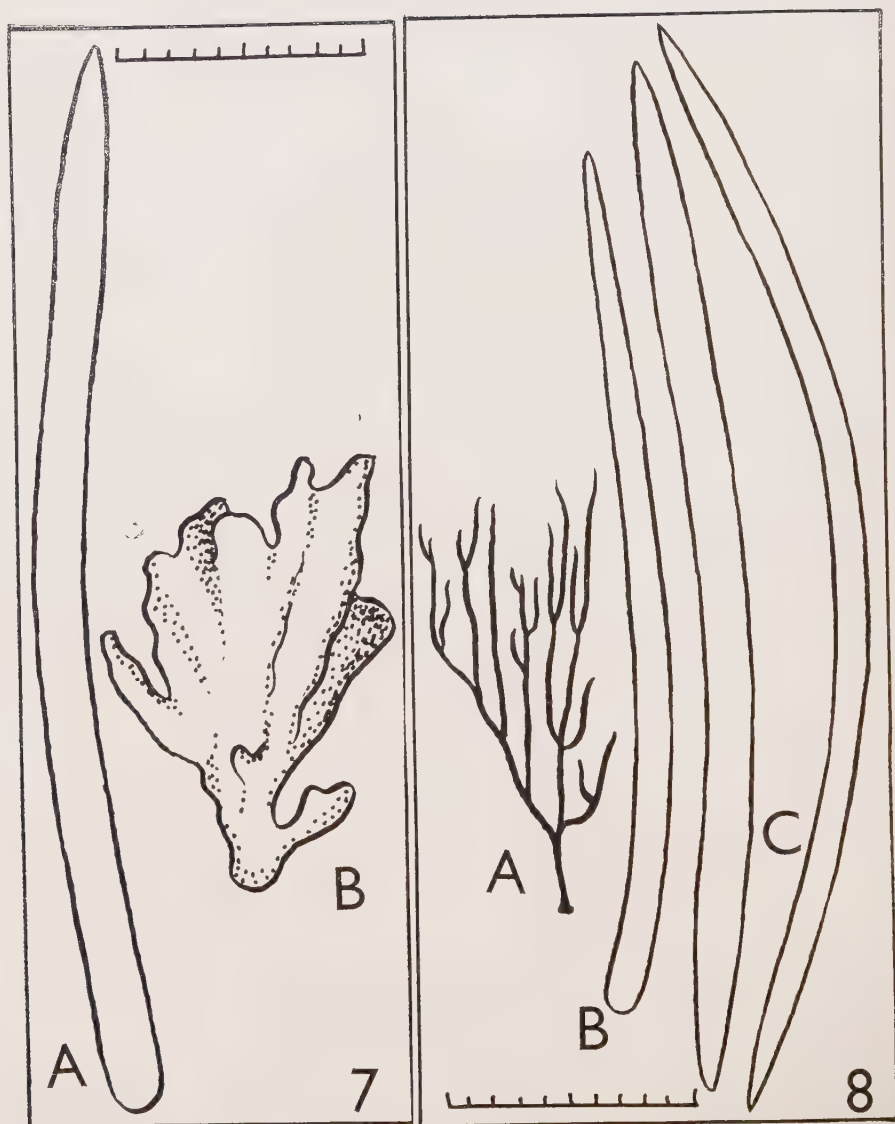


FIGURE 7. *Homaxinella waltonsmithi*. A: Camera lucida drawing of one of the spicules. This matches the enclosed scale, which shows 50 microns with 5-micron subdivisions. B: Free-hand sketch of part of the sponge, $\times 3/5$.

FIGURE 8. *Axinella polycapella*. A: Freehand sketch of a part of a specimen, $\times 1/11$. B: Camera lucida drawing of one of the styles. C: Camera lucida drawings of two of the oxes. B and C match the enclosed scale, which shows 50 microns divided into 5-micron units.

cludes a rather dense axis, whose diameter is about a third of that of the entire branch. In it the fibers or spicular tracts run predominantly lengthwise. Around it, they stand erect, perpendicular to it and to the surface of the sponge.

The spicules are of one sort only: smooth, often somewhat bent styles, 20 by 300 microns in dimensions.

This specimen is here identified with hesitation. Verrill (1907, page 297 or 341; two printings of the identical article have different pagination) described *Axinella rudis* from Bermuda. His description is so vague and omits so much of importance, that it could easily include the present specimen. He specified Bermuda, however, and there is an abundant species at that place which, more nearly than any other, fits Verrill's *A. rudis*. This is a *Homaxinella* and it was redescribed by de Laubenfels (1950, page 87). The present Gulf of Mexico specimen has spicules twice as thick as those of the Bermuda specimens of *rudis*, and a surface far less complex. It thus approaches two species of *Homaxinella*, the one described as *Axinella arborescens* by Ridley and Dendy (1886, page 479) from Australia, and the other described as *Axinella tenuidigitata* by Dendy (1905, page 189) from the Indian Ocean. The surmise is here advanced that the present specimen may be a deeper-water form of the species which is abundant in Bermudian shallow water, but it may be an occidental representation of one or both of the Australo-Indian Ocean sponges.

Homaxinella waltonsmithi new species

The holotype of this species is USNM 23407. The remainder of the same specimen is ML 4:072. This species was taken at station 20, depth 12.5 meters, 26 October 1948.

This is a flabellate, or palmate sponge, attaining a vertical measurement of 11 cm., and nearly as great a width. The width cannot be easily expressed in centimeters, because of the somewhat convoluted shape. The stem is nearly round, about 1 cm. in diameter. Most of the fan is about 6 mm. thick, but in some folds or ridges it is perhaps twice that. The upper edge is irregular, with some projections that are almost digitate. The color in life was bright orange-red; in alcohol it is pale drab. The consistency is spongy.

The surface is smooth to the naked eye, but with the microscope it is seen to be hispid. The apertures are all closed; doubtless they were very small.

The skeleton comprises a distinct axial region in contrast to a peripheral portion. The axis is about a third of the total thickness, but is

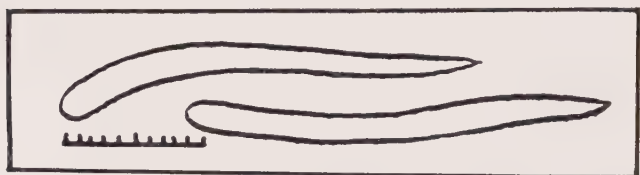


FIGURE 9. *Homaxinella rudis*. Camera lucida drawing of spicules. The enclosed scale shows 100 microns with 10-micron subdivisions.

more than a third where the thickness is greatest and less than a third in the thinner regions. The extra-axial region is often 2 or 3 mm. thick. In the axis, the main lines of spicular tracts are parallel to the surface, that is, they are erect, running up through the sponge from the base. In the extra-axial region, the tracts are perpendicular to the surface, and at the surface they end in erect tufts. These tracts are about 30 to 40 microns in diameter, usually about 4 spicules per cross section. They are often 200 to 230 microns apart, and are connected by single spicules placed like rungs in a ladder, about 200 to 250 microns apart. The spicules are exclusively smooth styles, about 10 by 220 microns.

This species is unique for its beautiful shape and for the smoothness of the surface. The specific name is given in respect to the eminent zoologist, F. G. Walton Smith.

Genus *Higginsia* Higgin

Higginsia strigilata (Lamarck) Topsent

This rather common West Indian sponge has long been known as *Higginsia coralloides* Higgin, but Topsent (1932, page 112) has shown that it is conspecific with Lamarck's *Spongia strigilata*. It is an orange or vermilion red sponge of exceedingly complex surface, with tubercles that are in turn tuberculate with tiny hispid tubercles. The species was redescribed (but still as *H. coralloides*) by de Laubenfels (1949, page 17).

It is represented in the collection by ML 4:136 (USNM 23425), taken at station 2, depth 9 meters, 24 September 1948. Notes indicate that a similar sponge, probably of this species, was also taken at station 19, but this station is not now represented by a specimen.

Family HYMENIACIDONIDAE de Laubenfels

Genus *Prianos* Gray

Prianos tierneyi new species

The holotype of this species is USNM 23408. The paratype is ML 4:228, taken at station 17, depth 7 meters, 3 October 1948.

It is an elaborate sponge, 20 cm. high and about 10 by 15 cm. in lateral measurement. There are two lobate towers, each with about a dozen or more oscules which are most abundant near the summits; there are also about a dozen lamellate protrusions rising like leaves, or in some cases like buttresses to the towers. These are often about 5 mm. thick and 5 cm. high. Field notes indicate that in life the exterior was "tan" color and the interior, white. The dry specimen, and the fragment in alcohol, are each dark mahogany or purplish externally and pale drab internally. The consistency is woody, or cork-like, resembling greatly that of *Sphaciospongia*. In fact, the whole appearance suggests *Sphaciospongia*.

The surface is exceptionally smooth. The numerous pores are about 135 microns in diameter, 400 microns apart. The oscules must have been about 5 or 6 mm. at least in diameter. They show indications of both sphincterate and iris-type closure. The ectosome is marked by a layer of cells (now very dark) blending into the endosome gradually. Nearly all the spicules that are right at the surface are perpendicular to it. Otherwise the spicules are packed in utter confusion. There are no definite tracts of spicules, nor fibers, just a cavernous endosome with felted masses of spicules in the dense tissues around the cavities. Many of the latter are as large as 1 cm. in diameter.

The spicules are smooth strongyles, about 9 by 260 microns in dimensions.

The genus *Prianos* was established by Gray (1867, page 520) for *Reniera amorpha* Schmidt 1864, a Mediterranean species of which the original description is not adequate. It was, however, a sponge whose only spicules were strongyles.

Burton (1930, page 512) said that *Reniera cratera* Schmidt 1862, from the same general region, and also ill-known, should be regarded as conspecific. Thus, the type should be called *Prianos craterus*.

The rather common and well known sponge which was called *Desmacidon columella* by Bowerbank (1874, page 243) was transferred to *Prianos* by de Laubenfels (1932, page 62); it may even be conspecific with *P. craterus*.

These European sponges were soft, especially in life, thus much like the genus *Batzella*.

A Californian sponge was named *Prianos problematicus* by de Laubenfels (1930, page 26). It is the closest to the present species. One might even erect a new genus for it and *P. tierneyi*. These two are stiff, and full of spicules, where the European *Prianos* is much more

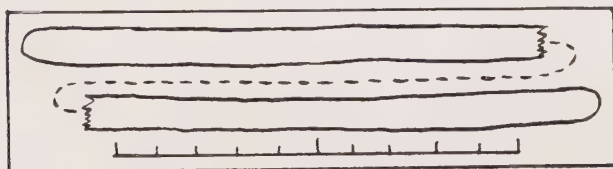


FIGURE 10. *Prianos tierneyi*. Camera lucida drawing of the spicule type (strongyle). The enclosed scale shows 100 microns subdivided into 10-micron units.

fleshy. The new species has the hardest consistency of all and is the least fleshy.

Prianos problematicus has a further difference from *tierneyi* in that it has some small (2 by 90 microns) oxeas among its spicules; furthermore, its strongyles are only 8 by 140 microns. Yet to have three genera, one for it, one for *craterus*, and another for *tierneyi*, does not now seem advisable, in spite of the fact that these three species differ in appearance so greatly that they might be in different orders!

The species is named in respect to J. Q. Tierney, with appreciation of his excellent work in amassing and preserving the present collection, and providing valuable field notes. Too many collectors merely toss many diverse species into a container without data as to appearance before preservation.

Genus *Hymeniacidon* Bowerbank

Hymeniacidon amphilecta de Laubenfels

This is the second occurrence of this species. A detailed description by de Laubenfels (1936, page 137) was based on a specimen taken in the Dry Tortugas, very close to the location from which the present specimen comes.

It is represented in the collection by ML 4:208, also by USNM 23409. It was taken at station 16, depth 20 meters, 3 October 1948.

Order HADROMERINA (or HADROMERIDA) Topsent

Family CHOANITIDAE de Laubenfels

Genus *Sphaciospongia* Marshall

Sphaciospongia vesparia (Lamarck) Marshall

This is the abundant sponge which is known in the Bahamas as "Manjack" and elsewhere as the "Loggerhead." It becomes larger than any other sponge in the world. Young specimens are erect in-

verted cones with a single large apical oscule. Older specimens contain many symbiont shrimp in large horizontal galleries, imprisoned by a sieve at the outer end.

This species is very widely distributed. It was taken from only a third of the stations, but there may have been specimens too large for the diver to dislodge, hence not collected.

Observations of many hundreds or even thousands of *Spheciospongia*s reveal the species *vesparia* as being regularly a dark dull grey-brown externally. It was reported as black by de Laubenfels (1936, page 141), but it is not that dark. On the other hand, Bermuda specimens do merit the term black. Their oscules are fewer and larger, hence they were given the species name *othella* by de Laubenfels (1950, page 94). It is also noted as an additional difference from *S. vesparia* that some Bermuda specimens exhibit streaks of tissue (external as well as internal) that are bright lemon yellow, in sharp contrast to the black bulk of the sponge, blending through green to the black. These streaks might be as large as 1 by 7 cm.

The puzzling situation now arises that the Second Gulf of Mexico Expedition, at station 20 (almost their farthest west station), found a *Spheciospongia* that was entirely bright yellow in life (ML 4:218). It is still pale dull yellow after preservation in alcohol. The spiculation is exactly that of *S. vesparia*, except that the spirasters are more abundant than is usual in *S. vesparia*. It would be very interesting to have specimens of *Spheciospongia* from still farther west in the Gulf. Perhaps there is a yellow race or species in the northern Gulf region.

Spheciospongia is represented in the collection by ML 4:218 (USNM 23410), taken at station 20, depth 12.5 meters, 26 October 1948 (not typical); by ML 4:221, taken at station 6, depth 12 meters, 27 September 1948; and by ML 4:068, taken at station 8, depth 14 meters, 29 September 1948. Notes indicate that it was also taken at stations 10, 13, and 21; these three are not now represented by specimens.

Genus *Spirastrella* Schmidt

Spirastrella coccinopsis new species (?)

The holotype of this provisional species is USNM 23411. The paratype (a portion of the holotype) is ML 4:219, taken at station 20, depth 12.5 meters, 26 October 1948.

This appears to be a massive or amorphous sponge, but it may have been an incrustation on a complex mass of dead organisms which have since disintegrated. A vertical measurement of 7 cm. is reached,

and thicknesses of over 1 cm. Altogether, there is at least a double handful of lumps and irregular pieces. The color in life is given as bright crimson, but the preserved specimen is pale brown. The consistency is stiffly crumbling (friable).

The surface is smooth over the gross lumpiness, and the apertures all appear to be closed. Doubtless they were very small. There is a dense ectosome, nearly 1 mm. thick, densely packed with spirasters. The endosome is cavernous, with spicules chiefly in utter confusion; a faint tendency toward the radiate structure can be noticed. The microscleres are fairly common in the interior, too, and the smaller, perhaps developmental, forms are found only there.

The spicules consist of tylostyles about 13 by 530 microns, thick spirasters 34 microns long, and thinner ones, only 20 microns long.

There are, throughout the oceans of the world, numerous sponges whose spiculation consists of tylostyles and spirasters. It may be that all of these should be in the genus *Spirastrella*. The type of *Spirastrella* is *S. cunctatrix* Schmidt (1868, page 17), an encrusting species, red to violet. There is an abundant West Indian species, *S. coccinea* Duch. and Mich. (1864, page 84), reddish brown in color. This or similar encrusting forms abound throughout the Pacific Ocean.

In the region of the Indian Ocean, East Indies, Australia and the South Pacific, there is a common massive species, brilliant purple in color, named *S. purpurea*. It has been widely assumed that the massive forms were merely older specimens of the species which were encrusting in youth. My field studies in the Pacific region have led me to doubt this. There is a notable lack of intermediate forms. There are small, yet already massive specimens that seem certainly to be the juveniles of the massive ones. It may even be advisable, as done in the family Microcionidae, to erect a special genus for the massive types, leaving only encrusting ones in the proper genus *Spirastrella*. In many parts of the Pacific, and—interestingly—in the whole West Indian region, there has been a lack of records of any except the encrusting type.

Now we have a massive sponge with the *Spirastrella* spiculation. It was collected so far to the west that it is barely on the margin of the West Indian region, yet it is West Indian. Its color in life (red-brown) and dead (pale brown) is like that of *S. coccinea*. It may indeed be an overgrown, aged specimen of *S. coccinea*. On the other hand, it may be an encrusting *S. coccinea* from which the original complex substrate has disappeared. Dead specimens of *S. purpurea* retain their

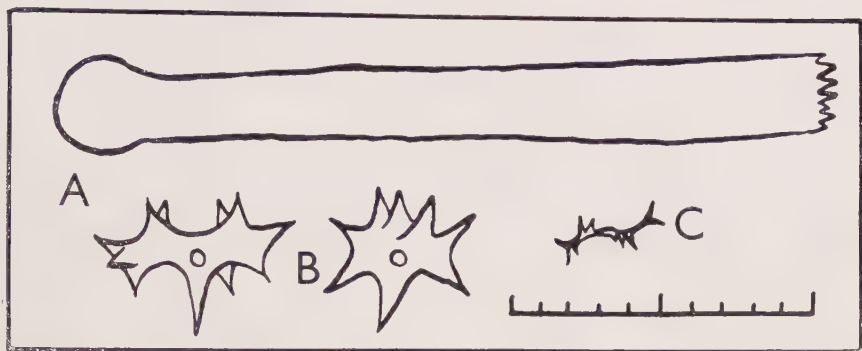


FIGURE 11. *Spirastrella coccinopsis*. Camera lucida drawings of spicules. A: Head only of one of the tylostyles. B: Coarser type of spiraster. C: Thinner, perhaps juvenile spiraster. These all match the enclosed scale, which shows 50 microns with 5-micron subdivisions.

purple color as this does not, yet it may be more closely related to *S. purpurea* than to *S. cunctatrix*.

Obviously, more knowledge about this and related species is much to be desired. Life histories need to be known. The present specimen may be placed elsewhere in some future revision, but in the interval, and for purposes of discussion in such a hypothetical revision, it may receive a convenient appellation, *coccinopsis*.

Genus *Anthosigmella* Topsent

Anthosigmella varians (Duch. Mich.) de Laubenfels

This species is both common and perplexingly variable in the West Indian region, deserving the specific name. Eventually one becomes able to recognize it by surface texture and consistency, and by the rather large, conspicuous oscules which are surrounded by paler tissue than that found elsewhere. The genus *Anthosigmella* is founded upon a very distinctive kind of microsclere. This is "C" shaped, with knobs along only the convex side. It is obviously a peculiarly modified spiraster. Many specimens of *A. varians* found growing within a few meters of one another, or even different parts of the same sponge, will show the following microsclere content:

1. All the microscleres distinctive (an easy identification.)
2. Most of the microscleres typical spirasters, but some distinctive.
3. All of the microscleres typical spirasters, and few of them.

4. No microscleres at all. This sort of sponge has often been called *Suberites distortus*.

Anthosigmella has been discussed in some detail by de Laubenfels (1949, page 19).

A. varians is represented in the collection by ML 4:216 (USNM 23412), by ML 4:217 (USNM 23413), and also by ML 4:222 (USNM 23414). All of these, showing great variation from one another, were taken at station 6, depth 12 meters, 27 September 1948. Notes indicate that yet another specimen, probably of this species, was taken at station 6, and another at station 20; these two are not now represented by specimens.

Family PLACOSPONGIIDAE Gray

Genus *Placospongia* Gray

Placospongia melobesioides Gray

This brown ramose sponge, with the hard, polygonal surface plates, has been discussed by de Laubenfels (1936, page 153).

It is represented in the collection by ML 4:200, taken at station 8, depth 14 meters, 29 September 1948.

Family CLIONIDAE Gray

Genus *Cliona* Grant

Cliona caribboea Carter

This abundant boring sponge leaves its mark on a considerable percentage of the shells, corals, and other calcareous items of the West Indies. It was doubtless present in its boring stage at many or all of the stations studied.

Unlike most members of the genus, but like the species *celata* (which it closely resembles), *C. caribboea* may grow up out of its burrows to become a large, massive sponge. It is then still recognizable because of the peculiar, soft, collapsible surface papilles, which correspond to those that protrude from the burrows of the still-hidden form. One such massive *Cliona* was collected in 1948.

It is represented in the collection by ML 4:220 (USNM 23415), taken at station 21, depth 6.5 meters, 27 October 1948. This is near the Florida State University station, at Alligator Point, Florida, in the immediate vicinity of which, massive *Clionas* appear to be exceptionally abundant.

Cliona lampa de Laubenfels

This *Cliona* has almost the spiculation of the species *vastifica*, but

it has a very different way of excavating. It was described by de Laubenfels (1948, page 110) from Bermuda (where it is superabundant), as permeating the entire substrate rather than merely excavating galleries. Exactly this method of growth is again revealed by the following specimens.

Cliona lampa (typical) is represented in the collection by ML 4:141 (USNM 23426), taken at station 22, depth 14.5 meters, 28 October 1948. Notes indicate that it was also taken at station 11, not now represented by specimens.

Order EPIPOLASIDA Sollas

Family JASPIDAE de Laubenfels

Genus *Prostylissa* Topsent

Prostylissa spongia new species

The holotype of the species is USNM 23416. The paratype (a portion of the holotype) is ML 4:226, taken at station 6, depth 12 meters, 27 September 1948. This species is also represented in the collection by ML 4:229 (USNM 23417), taken at station 4, depth 14.5 meters, 25 September 1948, and by ML 4:230 (USNM 23418), taken at station 19, depth 18 meters, 24 October 1948. Notes indicate that it was also taken at stations 10 and 17; these are not now represented by specimens.

New species are apt to be species that are uncommon. An abundant sponge, such as *Axinella polycapella* may be described as a new species after careful study, but it is not new in the sense of not having been previously collected. *Prostylissa spongia* appears in so many of the stations of the present collection that it must be astonishingly common. That it has not previously been collected may well be due to its appearance. In the field it looks so much like a *Spongia* that the scientific collector might not regard it as new and different. On the other hand, its texture is so different from that of good commercial sponges that the professional sponge fisher would reject it after touching it. It is interesting to note that the divers of the Second Gulf of Mexico Expedition did collect it. It is here assumed that they regarded these specimens as very inferior examples of *Spongia*.

The type of the species is lobate, an aggregate of eight or nine subglobular units. The other two specimens are simply globular. The type reaches a vertical measurement of 4 cm. and width of 9 cm. The

others are respectively 7 by 12 by 12 cm., and 6 by 9 by 9 cm. The color of the exterior is black, of the interior, drab. The consistency is somewhat spongy.

The surface is conulose, with conules about 2 mm. high and 4 mm. apart. The apertures are closed, but otherwise the resemblance to sponges of the genus *Spongia* is astonishingly great. The thin organic dermis resembles that of *Spongia*, but the endosome lacks the reticulate pattern.

The skeleton consists principally of large, smooth styles, about 30 by 880 microns. Their arrangement is definitely radiate, although (as in all large specimens that are fundamentally radiate) the interior of the sponge may be more or less in confusion. Within 1 to 3 cm. of the surface, the spicules are practically all perpendicular to the surface, with points toward it. There are no fibers and only vague groupings into tracts.

The endosome of this species is quite typical of the genus *Prostylissa*, but the surface is amazing. The species name is selected because of the great extent to which this sponge's ectosome resembles that of the genus *Spongia*.

Genus *Scolopes* Sollas

Scolopes megestra new species

The holotype of this species is USNM 23419. The paratype (a portion of the holotype) is ML 4:225, taken at station 7, depth 15 meters, 28 September 1948.

This is a subspherical sponge, about 10 by 13 by 15 cm. The color was drab in life. The consistency is woody.

The surface is exceedingly irregular. Many foreign organisms, including some sponge (*Haliclona viridis*) still adhere to its surface, and evidently others have been detached, leaving pits and scars. Smooth places can be found and may be significant. Apertures of 3 to 5 mm. diameter on some of the convexities may represent oscules. The pores are closed. There is a definite, well-marked organic dermis 20 microns thick. The interior is chiefly confused-cavernous, but traces of radiate structure can be discerned. There are many chambers about 100 microns in diameter; if they are flagellate (which is doubtful), they would be extraordinarily large ones.

The spiculation consists of very large, smooth oxeas, up to at least 55 by 2000 microns. Some thinner ones are probably juveniles. In places, there are many much smaller oxeas, which may constitute a

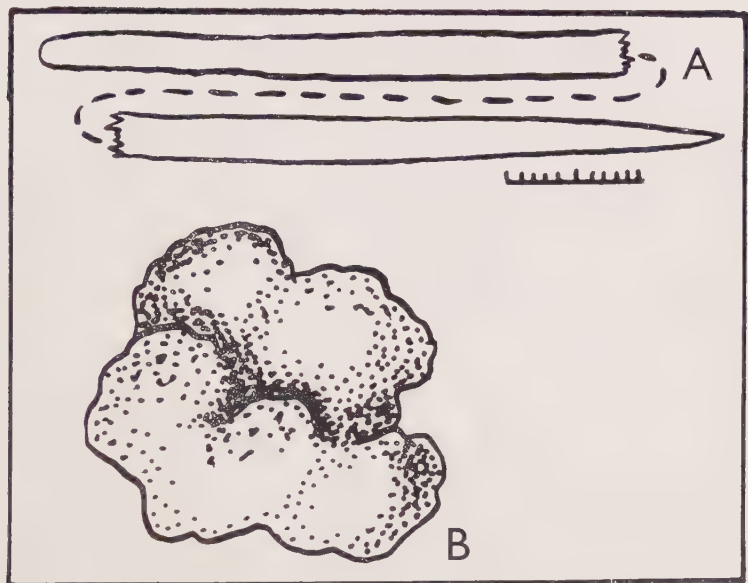


FIGURE 12. *Prostylissa spongia*. A: Camera lucida drawing of one of the spicules, in two installments. The entire spicule is shown. This matches the enclosed scale, which shows 100 microns with 10-micron subdivisions. B: Free-hand sketch of part of the sponge, x 2/3.

second category. On the other hand, some, or all of them, may be derived from the *Haliclona* that grew on the surface of the sponge. The microscleres are peculiar streptasters with strongylote rays, 17 to 22 microns in over-all length.

The genus *Scolopes* was established by Sollas (1888, page 432) for the species *moseleyi*, based on a single specimen from Bahia (now São Salvador), Brazil, latitude 13° S., depth unknown. The present specimen has very similar spiculation, but the microscleres of *S. moseleyi* were only 3 by 7 microns in size. The Brazilian species was extremely hispid or pilose as to surface, which *S. megastra* is not, and it had a much more conspicuous, or even fibrous, cortex than the thin one of *S. megastra*.

The genus *Paracordyla* should be dropped in synonymy to *Scolopes*. *Paracordyla* was established by Hallman (1912, page 132) for the one species *lignea*, from the coast of New South Wales, based on a single specimen. The present specimen from the Gulf of Mexico is

much like that Australian sponge in appearance and especially in consistency. Both have the very large oxeas and general architecture of the Epipolasida. There are great differences, too. Hallmann's specimen had microxeas, possibly but not certainly present in *megastra*, and its astrose spicules were only 4 microns in greatest dimension and so finely rayed that Hallman found it impossible to figure them. Microscleres most nearly like those of *S. megastra* are found only in sponges certainly or probably in the subfamily Thoosinae of the family Clionidae of the order Hadromerina, especially in a species originally named *Amphius huxleyi*.



FIGURE 13. *Scolopes megastra*. Camera lucida drawings of representative microscleres. The enclosed scale shows 50 microns with 5-micron subdivisions.

Sollas (1888, page 177) established the genus *Amphius* for the one species *huxleyi*, based on a single specimen from Api in the New Hebrides (South Pacific), depth 130 meters. Its microscleres are extremely similar to those of *S. megastra* except that the terminations to the rays are perhaps slightly more tylote. Like *S. megastra* and unlike *lignea*, the remainder of the spiculation consists only of megaxeas. This sounds as though *S. megastra* were congeneric with *A. huxleyi*. On the other hand, the megascleres of *A. huxleyi* are all small, 7 by 588 microns, and sparse, not at all characteristic of the order Epipolasida. Instead, the whole pattern is characteristic of massive specimens of Thoosinae; furthermore, as already remarked, in the Thoosinae (and practically nowhere else), there occur several genera with microscleres very much like those of *S. megastra*. The species *huxleyi*, like Thoosinae, and unlike epipolasid sponges, is soft, with very small flagellate chambers. Therefore, although not certainly boring, as are the other genera so placed, de Laubenfels (1936, page 156) put it provisionally in the Thoosinae. Another problem, however, arises in regard to it, as follows.

Genus *Neamphius* new name

This genus, of which the type is the sponge described as *Amphius huxleyi* by Sollas (1888, page 178, plate XLII, figures 5 to 11), is here provided with a new name, inasmuch as *Amphius* was previously employed by Gistel in 1834 for a coleopteran. The name is derived from *neo* (new) plus *amphius*, but with the "o" elided for euphony.

Family TETHYIDAE Gray

Genus *Tethya* Lamarck*Tethya diploderma* Schmidt

This is represented in the collection by two interesting specimens, warranting description. These constitute ML 4:201, taken at station 10, depth 12.5 meters, 30 September 1948.

As usual, each specimen is subspherical. The diameter is about 3 cm. The color in life was lemon yellow. The consistency is cartilaginous. The surface is highly tuberculate, with hemispherical tubercles, about 2 mm. in diameter. There is a tough cortex about 1 mm. thick, and the endosome is pronouncedly radiate. The megascleres are long strongyles, much thicker in the middle than at the ends. These fusiform diacts are found in few other genera. The microscleres include abundant spherasters, 50 to 60 microns in diameter; very abundant eutylasters, with the bulbous tips to their thin rays emphatically spined, total diameter 10 microns; a few oxyeuasters, with rays entirely microspined, diameter 45 microns; also a few smooth-rayed oxyeuasters of which, as a rule, one or more rays have bifurcated tips. These latter are about 50 microns in diameter.

This specimen is interesting in that it well illustrates the curious asexual reproduction of *Tethya*, which has, of course, long been known to occur. In some regions there is a certain time of the year for it to occur. The surface tubercles grow higher, not greater in diameter. Some protrude until they become stalked, or a spicule-filled stalk may be extruded, and a number of cells may crawl up it. In any case, a juvenile *Tethya* (nearly spherical) then begins to take shape, up on a stalk. This juvenile finally lets go, as it were, and falls, rolls, or is carried away. Presumably some of these detached buds find suitable localities, attach and grow.

It is consistent with this method of reproduction that when making an extended search one may go kilometers without finding any *Tethyas*, and then find a hundred within a few square meters.

The species *diploderma* was established by Schmidt (1870, page 52) for specimens from the West Indies.

Order CHORISTIDA Sollas

Family ANCORINIDAE Gray

Unimia new genus

This genus is here established, in the subfamily Theneinae of the family Ancorinidae, to have as its type the following species, *Unimia trisphaera*. As usual in this subfamily, there is a principal spiculation of tetraxons and large oxeas; also both streptasters and euasters occur as microscleres. *Unimia* is noteworthy for its lack of long-shafted triaenes, its only tetraxons being calthrops. It is more especially based upon the peculiar nature of its ectosome, which is an armored cortex densely packed with astrose microscleres. These approach in appearance the sterrasters of *Geodia* but are developed upon an elongate axis, rather than a point of radiation.

The name selected for this genus is based on the first three letters, respectively, of the words "University" and "Miami", thus showing respect to the institution which sponsored the study upon which this report is based.

Unimia trisphaera new species

The holotype of the species is USNM 23420. The paratype (a portion of the holotype) is ML 4:237, taken at station 20, depth 12.5 meters, 26 October 1948.

The sponge was probably spherical in life. As preserved dry, it has collapsed with many deep wrinkles, not as though there had been a single central hollow, but indicating the presence of numerous smaller cavities, which, in the aggregate, represented a large fraction of the original volume. Such extreme shrinkage is very unusual in sponges. The vertical measurement is 7 cm. and the lateral diameter is 11 cm. The color (dry) is a dark mahogany, almost black as to exterior, with a drab interior. No data as to appearance in life are given. There are indications that the field collectors did not regard this specimen as being a sponge.

The surface is smooth-punctiform. The pores, now closed, must have been at least 100 microns in diameter when open, one pore per square mm. About a dozen oscules can be made out, all concentrated within an area of five square cm. on the top of the sponge. Each has a diameter of about 5 cm. and a sharp rim, not raised, but turned inward.

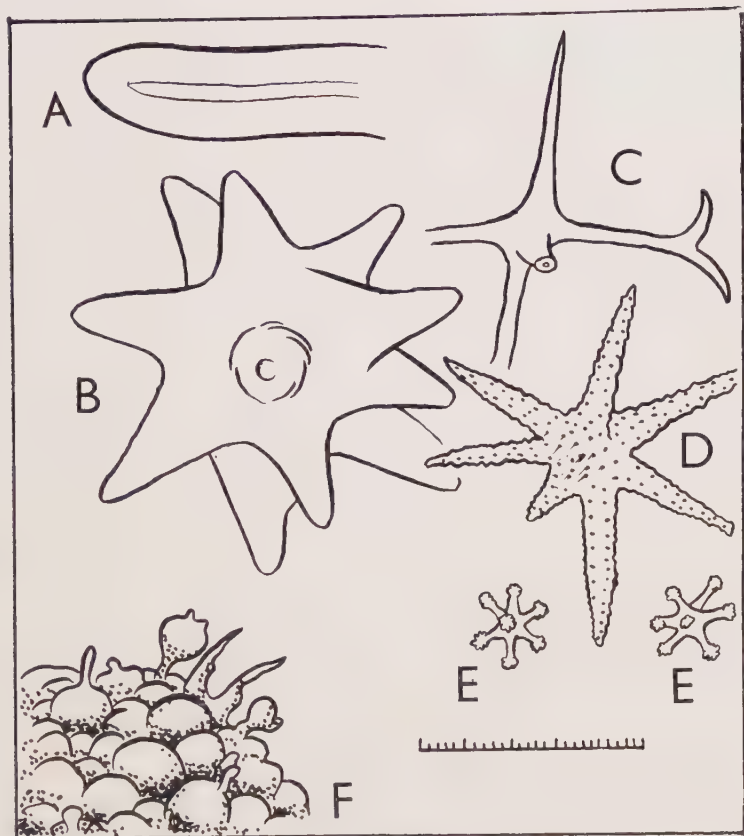


FIGURE 14. *Tethya diploderma*. A: One end of a megasclere. B: Spheraster. C: Oxyeuaster with bifurcated ray. D: Oxyeuaster, microspined. E: Eutylaster. These are camera lucida drawings and match the enclosed scale, which shows 25 microns. F: Freehand sketch of a bit of the surface of this sponge, showing several immature buds, two buds almost ready to leave the parent, and some stalks from which the buds have already left, $\times 2 \frac{2}{3}$.

There is a dense, leathery, contractile cortex, about 1 mm. thick, packed with the peculiar sterraster-like trispaeroid streptasters. The endosome is fundamentally radiate in plan, but as usual in sponges that are so large, the central endosome is in confusion. Near the surface, the spicular tracts are perpendicular to it.

The abundant megascleres are smooth oxeas about 12 by 900 microns. A few calthrops-like tetraxons were found, with all angles of divergence about equal and rays up to 12 by 270 microns. Many of these rays have rounded (stronglote) ends, rather than pointed (oxeote) ends.

There are several kinds of microsclere, all abundant. There are oxyeuasters 12 microns in diameter; these may be juveniles. There are euacanthochiasters, and eutylasters that are also slightly acanthose, up to 24 microns in diameter. There are smooth microxeas which vary through intermediate shapes to microstrongyles. The spicules of this category are 2 by 50 microns. There are numerous streptasters which are obviously juveniles of the dermal spicules; these are often about 80 microns long. Their spines are exceedingly long and sharp, and instead of being at right angles to the axis of the spicule, they radiate from its central point. All intermediates may be found between this and the mature dermal spicules. These latter are

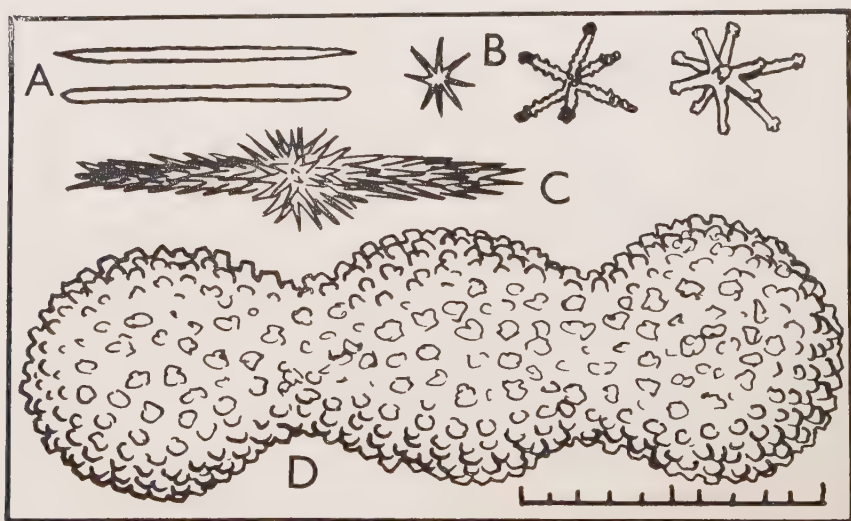


FIGURE 15. *Unimia trisphaera*. Camera lucida drawings of the microscleres. A: Microxea and microstrongyle. B: Various representative shapes of the euasters. C: Juvenile of the dermal spicule. D: Mature dermal spicule. The megascleres are not shown. The spicules shown match the enclosed scale, which shows 50 microns divided into 5-micron units.

about 135 microns long, and the spheres range from 40 to nearly 50 microns in diameter. The spines finally become tuberculate and blunted, exactly as do the spines of the sterrasters of *Geodia*.

The species name of this unique sponge is based on the shape of these dermal spicules.

Genus *Stelletta* Schmidt

Stelletta grubii Schmidt

This is represented in the collection by ML 4:233 (USNM 23421), taken at station 20, depth 12.5 meters, 26 October 1952.

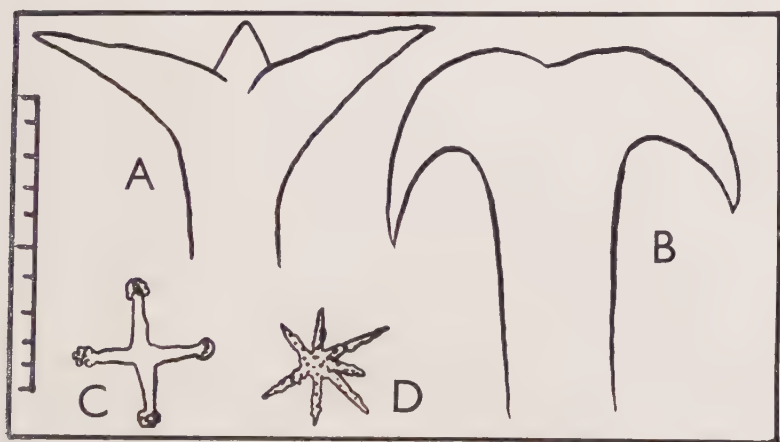


FIGURE 16. *Stelletta grubii*. Camera lucida drawings of spicules. A: Head of plagiotriaene. B: Head (or cladome) of anatriaene. These two match the enclosed scale, which shows 50 microns with 5-micron subdivisions. C: Eutylaster with microspined terminations. D: Oxyeuaster entirely microspined. C and D are magnified twice as much as A and B.

This is a subspherical sponge about 12 cm. in diameter, very pale and almost white, and cartilaginous in consistency. The surface is profusely encumbered with foreign debris, especially the shells of Pelecypoda. The pores and oscules cannot be certainly detected.

There is a dense tough white cortex two mm. thick, within which is a fairly dense but softer endosome, permeated by spicules and spicule tracts in radiate arrangement.

There are fewer oxeas in proportion to the triaenes than is usual. They are about the same size as the rhabds of the triaenes, say 16 by 500 microns. The commonest tetraxon type, perhaps the commonest megasclere of all, is a plagiotriaene. The chord measurement is 60 microns and the rhabd (like that of the plagiotriaene) measures 16 microns in diameter.

The species *grubii* was established by Schmidt (1862, page 46) for Mediterranean sponges.

Genus *Myriastr*a Sollas

*Myriastr*a *debilis* Thiele

This is represented in the collection by ML 4:235 (USNM 23422), taken at station 19, depth 18 meters, 24 October 1948.

This is a massive sponge about 15 cm. high and 12 cm. in diameter. Its color in life was brown and gray externally and nearly white internally, according to field notes. In alcohol the exterior is dark brown, the interior, ochraceous drab. The consistency is cartilaginous. The surface is extremely lumpy and irregular. Oscules and pores cannot certainly be detected. There is a vague cortex, not outstandingly tough, about 1 mm. thick. The endosome is definitely radiate.

The spicules are predominantly huge oxeas up to at least 70 microns in diameter, and over 2 mm. long. There are also certainly plagiotriaenes with rhabds of about this same size range, chords of the cladome 150 microns in diameter. The microscleres are oxyeuasters, 11 to 14 microns in diameter, all essentially of the same category.

This species was described by Thiele (1900, page 25) from the East Indies. Uliczka (1929, page 29) reported it from the vicinity of the Dry Tortugas. It is remarkable within the genus for having oxyeuasters. Another with oxyeuasters (but these acanthose) is *tuberosa*, described as *Astrella tuberosa* by Topsent (1892, page 44). This is not the same as *Myriastr*a *tuberosa*, described as *Stelletta tuberosa* by Hentschel (1909, page 353); therefore, a new designation is required for the latter. It is here proposed that it receive the new name *Myriastr*a *hentscheli*.

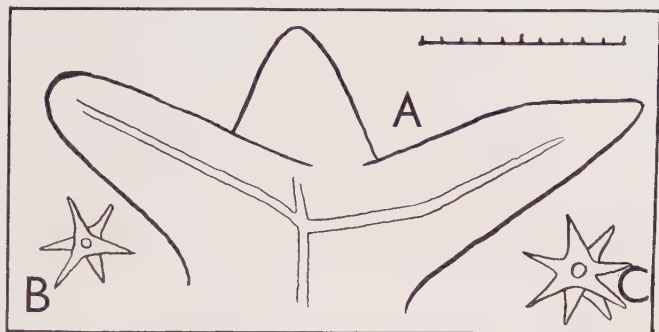


FIGURE 17. *Myriastrea debilis*. Camera lucida drawings of spicules. A: Head or cladome of the plagiotriaene, matching the enclosed scale, which shows 50 microns with 5-micron subdivisions. B and C: Oxyeuasters, magnified twice as much as A.

Family GEODIIDAE Gray
Genus *Geodia* Lamarck
Geodia gibberosa Lamarck

This well known species, with its oscules and pores in the form of saucer-like sieves, and its tough, hard, sterraster-loaded armor, was redescribed in some detail by de Laubenfels (1936, page 172).

It is represented in the collection by ML 4:244, taken at station 8, depth 14 meters, 29 September 1948; ML 4:238, taken at station 10, depth 12.5 meters, 30 September 1948; ML 4:236, taken at station 20, depth 12.5 meters, 26 October 1948; and ML 4:231 (USNM 23423), taken at station 15, depth 17 meters, 3 October 1948. This last was mustard brown in life, according to field notes, and is dark walnut brown in alcohol. This color is unexpected for the species *gibberosa*, and some possibility exists that this is another species. There seems, however, to be little other difference than in color, which might be due to foreign overlay.

Family CRANIELLIDAE de Laubenfels
Genus *Cinachyra* Sollas
Cinachyra cavernosa (Lamarck) de Laubenfels

The genus *Cinachyra* is represented in the collection by ML 4:198, taken at station 14, depth 12 meters, 2 October 1948, and by ML 4:234, taken at station 13, depth 19 meters, 2 October 1948.

It is represented in the West Indies, according to Uliczka (1929, page 41), by half a dozen species. These are separated by very slight differences, however, and all may be synonyms of *C. cavernosa*.

As an additional complexity, some specimens which were distorted by their neighbors in life, or damaged in collection, are scarcely to be differentiated from the genus *Craniella*. This applies to both of these present specimens. Each is identified with some hesitation; neither is typical. For further description see de Laubenfels (1949, page 21, and 1936, page 174).

ANALYSIS BY STATIONS OF SPONGE COLLECTIONS

Sta. 1. 24 September 1948, depth 5.5 meters, 9.6 kilometers WNW of John's Pass. Lat. $27^{\circ} 49' N.$, Long. $82^{\circ} 53' W.$ The expedition set out southward from Tarpon Springs, Florida, the principal home port of the sponge fishing fleet. Only one sponge species was reported from this first station.

Axinella polycapella

Sta. 2. 24 September 1948, depth 9 meters, 5.6 kilometers W by N of John's Pass. Lat. $27^{\circ} 48' N.$, Long. $82^{\circ} 58' W.$ This is still near St. Petersburg, Florida, in waters once famous for abundance of commercial sponges. Again only one species was taken.

Higginsia strigilata

4:136⁴

Sta. 3. 24 September 1948, depth 10 meters, 16 kilometers NW by W of New Pass buoy. Lat. $27^{\circ} 25' N.$, Long. $82^{\circ} 45' W.$ This is about 40 kilometers south of station 2. No sponges at all were taken.

Sta. 4. 25 September 1948, depth 14.5 meters, 11 kilometers W of Boca Grande sea buoy. Lat. $26^{\circ} 40' N.$, Long. $82^{\circ} 27' W.$ Five species of sponge were taken.

Ircinia fasciculata 4:050

Aplysilla sulfurea 4:212

Axinella polycapella

Homaxinella rudis 4:060

Prostyliissa spongia 4:229

Sta. 5. 26 (?) September 1948, depth 11.5 meters, 27 kilometers N by W of Boca Grande buoy. Lat. $26^{\circ} 23' N.$, Long. $82^{\circ} 14' W.$

Ircinia campana

Dysidea fragilis

Axinella polycapella

Sta. 6. 27(?) September 1948, depth 12 meters, 14.4 kilometers W of Big Marco Pass. Lat. $25^{\circ} 58' N.$, Long. $81^{\circ} 55' W.$

Spongia sp. ("bastard wire sponge")

Ircinia campana

Ircinia strobilina

Neopetrosia longleyi 4:078

Axinella polycapella

Anthosigmella varians

three specimens 4:216, 4:217, 4:222

Sphecciospongia vesparia 4:221

Prostyliissa spongia 4:226

⁴ This number and those below are ML numbers.

Sta. 7. 28 September 1948, depth 14 meters, 22.4 kilometers W of Cape Romano whistle buoy. Lat. $25^{\circ} 40' N$, Long. $81^{\circ} 55' W$. This is, of all 22 stations, the farthest from the nearest land.

<i>Ircinia campana</i>	
<i>Dysidea crawshayi</i>	4:227
<i>Fibulia massa</i>	4:210
<i>Scolopes megastra</i>	4:225

Sta. 8. 29 September 1948, depth 14 meters, 5 kilometers W of Smith Shoal light, about 15 kilometers NW by N from Key West, Florida. Lat. $24^{\circ} 43' N$, Long. $81^{\circ} 58' W$.

<i>Ircinia campana</i>	4:194
<i>Ircinia strobilina</i>	
<i>Verongia longissima</i>	4:149
<i>Haliclona viridis</i>	4:151
<i>Fibulia</i> sp.	
<i>Mycale angulosa</i>	
<i>Dictyociona adioristica</i>	4:214
<i>Spheciospongia vesparia</i>	4:068
<i>Placospongia melobesioides</i>	4:200
<i>Geodia gibberosa</i>	4:244

Sta. 9. 29 September 1948, depth 13 meters, 6.4 kilometers SW by S of Smith Shoal light. Lat. $24^{\circ} 41' N$, Long. $81^{\circ} 58' W$. This is less than 6 kilometers from station 8, yet only one sponge was taken.

<i>Axinella polycapella</i>	4:202
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Sta. 10. 30 September 1948, depth 12.5 meters, 17.6 kilometers W of Smith Shoal light. Lat. $24^{\circ} 42' N$, Long. $82^{\circ} 07' W$.

<i>Ircinia strobilina</i>	4:243
<i>Ircinia campana</i>	4:062
<i>Dysidea fragilis</i>	4:205
<i>Callyspongia vaginalis</i>	4:185
<i>Myrmekioderma styx</i>	4:211
<i>Echinostylinos unguiferus</i>	4:215
<i>Axinella polycapella</i>	
<i>Spheciospongia vesparia</i>	
<i>Tethya diploderma</i>	4:201
<i>Prostylissa spongia</i>	
<i>Geodia gibberosa</i>	4:238

Sta. 11. 1 October 1948, depth 11 meters, 3 kilometers W of Ellis Rock. Lat. $24^{\circ} 39' N$, Long. $82^{\circ} 13' W$. This is very close to station 10.

<i>Ircinia strobilina</i>	4:066
<i>Ircinia campana</i>	
<i>Mycale angulosa</i>	4:239
<i>Axinella polycapella</i>	
<i>Cliona lampa</i>	

Sta. 12. 1 October 1948, depth 6 meters, 13 kilometers E by N of Rebecca Shoal light. Lat. $24^{\circ} 36' N$, Long. $82^{\circ} 27' W$. No sponges were collected.

Sta. 13. 2 October 1948, depth 19 meters, 3 kilometers WSW of Rebecca Shoal light. Lat. $24^{\circ} 34' N$, Long. $82^{\circ} 37' W$.

<i>Spongia</i> sp. ("wire sponge")	
<i>Ircinia fasciculata</i>	
<i>Ircinia campana</i>	
<i>Ircinia strobilina</i>	

Haliclona rubens 4:196

Dasychalina cyathina

Xestospongia muta 4:223

Mycale angulosa 4:197

Axinella polycapella

Spheciospongia vesparia

Cinachyra cavernosa 4:234

and one other, not identified or preserved

Sta. 14. 2 October 1948, depth 12 meters, 5 kilometers S of Loggerhead Key light. Lat. $24^{\circ} 35' N$, Long. $82^{\circ} 55' W$. This is extremely close to the Dry Tortugas, but the best collecting was formerly considered to be just east of, rather than south of Loggerhead Key.

Ircinia fasciculata

Ircinia campana

Verongia longissima

Ianthella ardis 4:199

Dasychalina cyathina 4:206

and a second specimen, not preserved

Callyspongia vaginalis 4:240

and two other specimens

Iotrochota birotulata 4:207

Cinachyra cavernosa 4:198

Sta. 15. 3 October 1948, depth 17 meters, 14.4 kilometers W of Loggerhead Key light. Lat. $24^{\circ} 38' N$, Long. $83^{\circ} 02' W$.

Ircinia strobilina

Xytopsues griseus 4:224

Geodia gibberosa 4:231

Sta. 16. 3 October 1948, depth 20 meters, 14.4 kilometers NW by N of Loggerhead Key light. Lat. $24^{\circ} 43' N$, Long. $82^{\circ} 59' W$. This list of species looks much like the results of a day's collecting near the old Carnegie Institution Laboratory at the Dry Tortugas.

Ircinia strobilina

Verongia fistularis 4:070

Verongia longissima 4:195

Ianthella ardis 4:241

Haliclona rubens

Dasychalina cyathina

Rhizochalina hondurasensis 4:209

Callyspongia vaginalis, two specimens, not preserved

Iotrochota birotulata

Mycale angulosa

Hymeniacidon amphilecta 4:208

Sta. 17. 3 October 1948, depth 7 meters, 5 kilometers N of Loggerhead Key light. Lat. $24^{\circ} 41' N$, Long. $82^{\circ} 55' W$. This is the station nearest to the old Carnegie Institution Laboratory.

Ircinia campana

Ircinia strobilina

Callyspongia vaginalis

Prianos tierneyi 4:228

Prostylixa spongia

Sta. 18. 11 October 1948, depth 14 meters, 29 kilometers SE of Ochlockonee

Shoal bell buoy 24. Lat. $29^{\circ} 39' N$, Long. $83^{\circ} 56' W$. This is up at the far northeast corner of the Gulf of Mexico.

Hippiospongia lachne 4:242

Axinella polycapella

Sta. 19. 24 October 1948, depth 18 meters, 13 kilometers W by N of Laguna Beach. Lat. $30^{\circ} 16' N$, Long. $86^{\circ} 04' W$. This is very close inshore, the farthest north and west of all 22 stations.

Ircinia fasciculata 4:204

Ircinia campana

Ircinia strobilina

Verongia aurea 4:192

Verongia longissima

Axinella polycapella

Higginsia strigilata

Prostylissa spongia 4:230

Myriastrea debilis 4:235

Sta. 20. 26 October 1948, depth 12.5 meters, 13 kilometers NE of East Pass sea buoy. Lat. $29^{\circ} 50' N$, Long. $84^{\circ} 32' W$. This is close inshore. It yielded the greatest variety of sponges.

Aulena columbia 4:147

Ircinia fasciculata

Ircinia campana

Verongia longissima

Darwinella mülleri 4:203

Callyspongia vaginalis

Axinella polycapella

Homaxinella waltonsmithi 4:072

Anthosigmella varians

Spirastrella coccinopsis 4:219

Spheciospongia vesparia 4:218

Stelletta grubii 4:233

Geodia gibberosa 4:236

Unimia trisphaera 4:237

Sta. 21. 27 October 1948, depth 6.5 meters, 14.4 kilometers NE by N of Ochlockonee Shoal bell buoy 24. Lat. $29^{\circ} 59' N$, Long. $84^{\circ} 05' W$.

Spongia zimocca 4:183

Spongia graminea 4:138

Spongia graminea 4:181

Ircinia campana

Verongia sp.

Haliclona viridis 4:213

Thalysseurypon vasiformis 4:232

Axinella polycapella

Cliona caribboea 4:220

Spheciospongia vesparia

Sta. 22. 28 October 1948, depth 14.5 meters, 29 kilometers SE of Ochlockonee Shoal bell buoy 24. Lat. $29^{\circ} 39' N$, Long. $83^{\circ} 56' W$. This is the same location as station 18.

Hippiospongia lachne 4:139

Hippiospongia gossypina 4:182

Ircinia fasciculata

Axinella polycapella

Cliona lampa 4:141

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CONTRIBUTIONS will be considered which deal with research in the marine sciences, directly or indirectly related to the southeastern United States and the Caribbean area. Papers dealing solely with the economic or applied aspects of commercial fisheries will not be accepted.

Manuscripts may be submitted in languages other than English but publication will be in English only. Where possible, arrangements will be made for translation.

All copy should be typewritten and double spaced. Footnotes should be avoided as far as possible. If used they should be numbered continuously throughout the paper and set off in the body of the text.

Bibliographical references must be indicated by author's name and year of publication. References should be listed under that heading in alphabetical order of authors. Each reference should include the last name followed by initials or the first name. Co-authors should be listed with initials preceding the last name. The date should appear next to the author's name, followed by a complete title, in lower case except for the first word. The publisher, city and pagination should follow, in the case of books. The names of periodicals should be abbreviated as in "World List of Scientific Periodicals," Oxford. The volume is then given in arabic numerals underlined for italics, followed by the number in brackets and the pagination preceded by a colon. After the first line of each reference the copy is indented.

Figures must be submitted with the manuscript, either as originals or photographs. Half-tone reproductions should be avoided where possible. Large numbers of tables or illustrations will usually be accepted only if arrangements are made by the author or his institution to contribute towards the cost. The proper size of lines, characters and symbols must be used and illustrations must be of such a size that they may be reduced by at least 2/3. Mechanical lettering should be employed. Alternatively, lettering may be indicated on a translucent paper cover, for setting by the editorial office. Tables should be simple and with a minimum of rulings. Legends should be typed on a separate sheet with proper identification by illustration number at the end of the manuscript. A brief abstract should accompany each contribution.

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